ELECTRICAL ENGINEERING

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APRIL
1953

The Cover: Looking up at the 2,000-kv Westinghouse surge generator erected at the open end of the highly insulated experimental lines of the American Gas and Electric Company at Brilliant, Ohio. This equipment is being used for artificial lightning tests as described in the article on pages 287–8.

A Redefinition of AIEE Membership Grades........................C. W. Franklin . . . 281
The Deductive Method in the Physical Sciences.................Henry Margenau . . . 284
Field Surge Testing of Extra-High-Voltage Lines.....Philip Sporn, A. C. Monteith . . . 287
UNIVAC on Election Night..A. F. Draper . . . 291
The Equipment Manufacturer and Power Education...........H. N. Muller, Jr. . . . 295
Dynamic Braking on Diesel-Electric Locomotives.....A. V. Johansson, H. R. Stiger . . . 300
Why Options Anyway?..K. B. McEachron, Jr. . . . 305
Automatic Cruise-Control Computer for Long-Range Aircraft.........J. R. Shull . . . 309
Maintenance of Electric Equipment in Modern Aircraft............A. J. Mustard . . . 312
India's High-Voltage Laboratory....................G. K. M. Pfestorf, D. J. Badkas . . . 320
New High-Voltage Outdoor Load-Interrupter Switch....H. J. Lingal, J. B. Owens . . . 324
Electrostatic Safety for Hospital Operating Rooms..........................Robin Beach . . . 329
Electronic Instruments for Production Testing Camera Shutters R. W. Lavender . . . 336
Improving Gas-Tube Grid Circuit Reliability.............................J. H. Burnett . . . 341
A New Universal Right-Hand Rule..P. M. Honnell . . . 346
A New Unity Plan Proposal................J. C. Dutton, W. J. Degnan, J. L. Oprisch . . . 349
Trends in Rapid-Transit Car Design.....................................S. H. Bingham . . . 352

TECHNICAL PAPER DIGESTS

Amplidyne Voltage Regulator for Turbine Generators.........W. A. Hunter, M. Temoshok . . . 289
A New Property of 2-Dimensional Fields...A. D. Moore . . . 290
Self-Balancing Potentiometer-Type Magnetic Amplifiers.........................W. A. Geyger . . . 294
Field Studies of Generator Windings..H. C. Marcroft . . . 298
Cathode-Drift Compensation in D-C Amplifiers...............................J. W. Rittenhouse . . . 299
New Heavy-Duty 3-Phase Oil Circuit Recloser.................................Anthony Van Ryan . . . 307
An Improved Magnetic Servo Amplifier.........C. W. Lufcy, A. E. Schmid, P. W. Barnhart . . . 308
Sleet-Melting Practices: Niagara Mohawk System..............H. B. Smith, W. D. Wilder . . . 318
Power-Line Carrier System Line Traps...J. D. Moynihan . . . 319
Review of Backup Relaying Practices.....................................AIEE Committee Report . . . 328
Arc Quenching in Sulphur Hexafluoride........H. J. Lingal, A. P. Strom, T. E. Browne, Jr. . . . 335

MISCELLANEOUS SHORT ITEMS: Oak Ridge Cyclotron, 286; New Coaxial Cable System, 288; Electronic Control Device, 293; Cesium-Beam Atomic Clock, 297; Magnetic Attenuator, 306; Single-Tone Selective Signaling System, 317; New Oil Circuit Breaker, 327; Furnace Dust Recovered, 340; Jet Autopilot, 355

Institute Activities.. . . . 356
AIEE Personalities, 367; Obituary, 370; Membership, 370

Of Current Interest.. . . . 371
Letter to the Editor, 377; New Books, 378; Pamphlets, 378

Industrial Notes.. . . . 18A
New Products, 22A; Trade Literature, 64A

Index to Advertisers.. . . 102A

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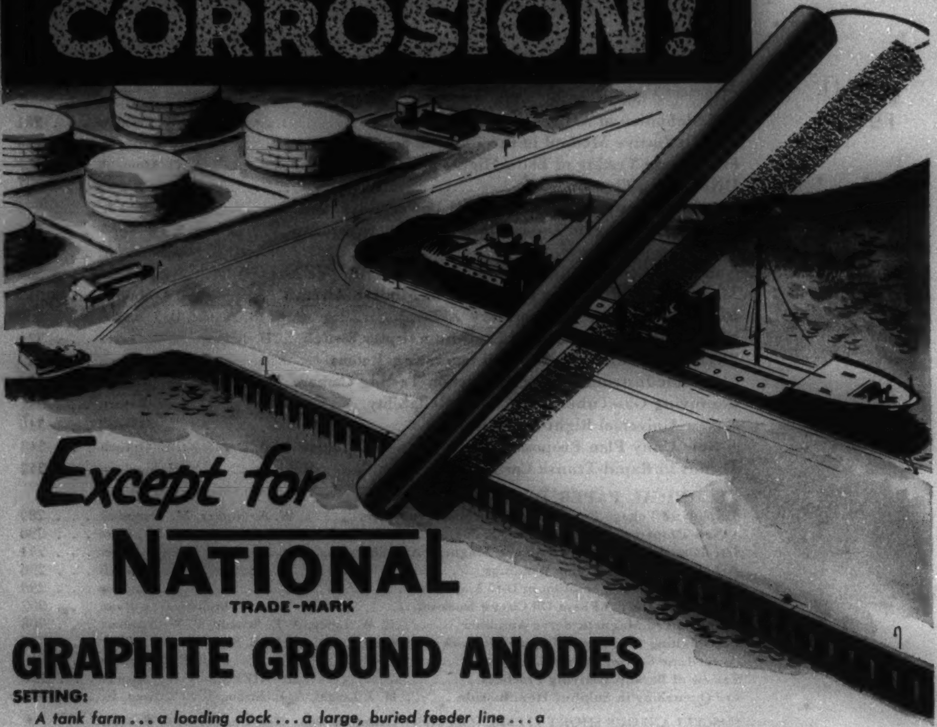

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HIGHLIGHTS ....

Redefinition of Membership Grades. As a result of recent amendments to the AIEE Constitution, the requirements for the various grades of AIEE membership have been redefined. This brief review is presented as an aid to those who may not have followed these changes in detail (*pages 281–4*).

The Equipment Manufacturer and Power Education. Opportunities that the manufacturer of power equipment has to offer young engineers and the reasons for the lack of interest in power education are discussed. Current developments in power generation, transmission, and distribution provide stimulating professional work for young men choosing that field (*pages 295–7*).

Why Options Anyway? A discussion of options in curricula also must concern itself with the function of such options in helping achieve the broad objectives of engineering education. The reasons for such breakdowns in curricula and possible alternatives are described (*pages 305–06*).

Field Surge Testing of High-Voltage Lines. The objectives of this artificial lightning test program now being conducted to obtain extra-high-voltage data are presented together with a brief description of the equipment being used (*pages 287–8*).

New Unity Plan Proposal. In this article, members of the Pittsfield General Electric Engineers Association present their plans for a Unity Organization which would include all members of the engineering profession, with the maximum of participation by the members at the local level in shaping policies (*pages 349–51*).

News Index

Institute Activities 356

Southern District Meeting 356
Future AIEE Meetings 356
North Eastern District Meeting 358
Board of Directors Meets 361
Electronic Components Symposium 363
Committee Activities 366
AIEE Personalities 367
Obituary 370
Membership 370

Of Current Interest 371

Electronic Flowmeter 371
Future Meetings of Other Societies 371
Telojector for Television Stations 372
Littrow-Echelle Spectrograph 373
A-C Network Analyzer 374
Letter to the Editor 377
New Books 378
Pamphlets 378

A New Universal Right-Hand Rule. This one new rule supersedes both of Fleming's right-hand rules, dated nearly 70 years ago. With it you can predict the direction of the force on a conductor and the direction of a generated electromotive force (*pages 346–9*).

Electronic Instruments for Production Testing of Camera Shutters. A brief description of some of the instruments used by one camera manufacturing company for the quality control and testing of its camera shutters is presented in this article (*pages 336–40*).

Dynamic Braking on Diesel-Electric Locomotives. Originally intended as a means of controlling both passenger- and freight-train speed on mountain grades, dynamic braking has been refined to the point where it is increasingly used for controlling freight-train speed in relatively level territory. A discussion of the control equipment will be found in this issue (*pages 300–05*).

Automatic Cruise-Control Computer for Long-Range Aircraft. This article presents a qualitative discussion of present manual cruise-control technique and describes a proposed cruise-control computer for long-range military aircraft. A mechanization of the computer is described together with its operation and a comparison of the automatic system with manual techniques given (*pages 309–12*).

New High-Voltage Outdoor Load-Interrupter Switch. This unit is designed to make available at transmission voltages a dependable and economical outdoor circuit interrupter. It is completely self-contained, requiring no external gas supply or other auxiliary apparatus for operation, and the switch is long-lived as shown by numerous tests (*pages 324–7*).

UNIVAC's Predictions of the National Election Results. The computer made its debut to the world's largest television audience for this purpose. Both the mathematical theory which had to be developed in advance and the actual setup to process the data on election night are covered here (*pages 291–3*).

India's Larger High-Voltage Laboratory. It is located at Bangalore and will be instrumental in furthering research, the training of personnel, and in conducting electrical tests both for science and industry. The equipment is described as well as the kinds of experimentation already under way (*pages 320–4*).

The Deductive Method in the Physical Sciences. The narrower strictly inductive approach to science is deprecated as ignoring some of the theoretical or ideal elements necessary to true scientific understanding. Sciences are classified as correlational and theoretical. The latter type utilizes both induction and deduction (*pages 284–6*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District Meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Electrostatic Safety for Hospital Operating Rooms. A description of how static electricity is generated is followed by a discussion of safety factors in operating rooms. Conductive floors and electrostatic hazard alarms are given considerable attention (*pages 329–34*).

Maintenance of Electric Equipment in Modern Aircraft. The design of electric equipment and its location in an airplane determines whether its maintenance is easy or difficult. Some of the factors involved in this important activity will be found in this article by a maintenance engineer (*pages 312–17*).

Improving Gas-Tube Grid-Circuit Reliability. Some designers have felt that thyratrons are to a certain extent unpredictable in performance and so have not used them as much as possible. If more engineering attention were given to this tube's grid circuit, it is felt that better results would be obtained (*pages 341–6*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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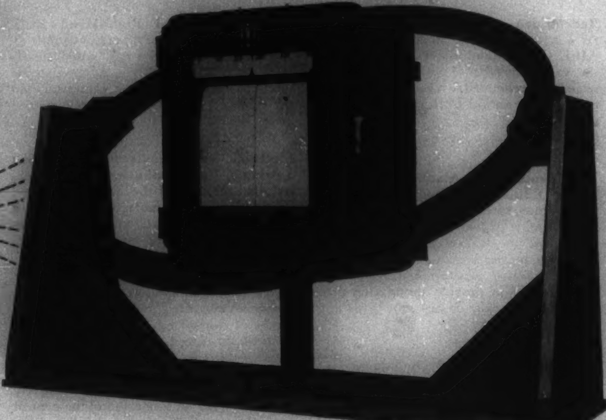

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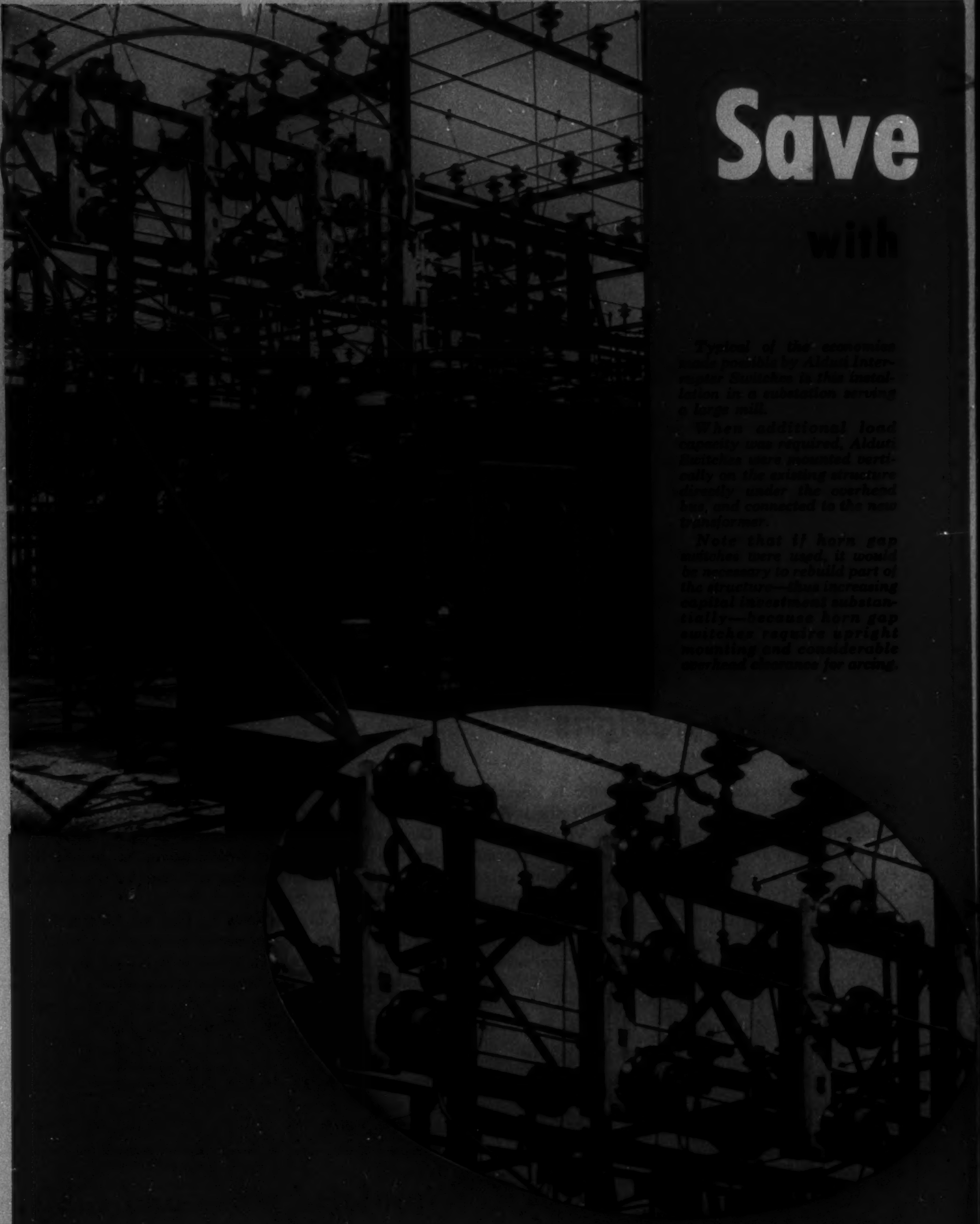

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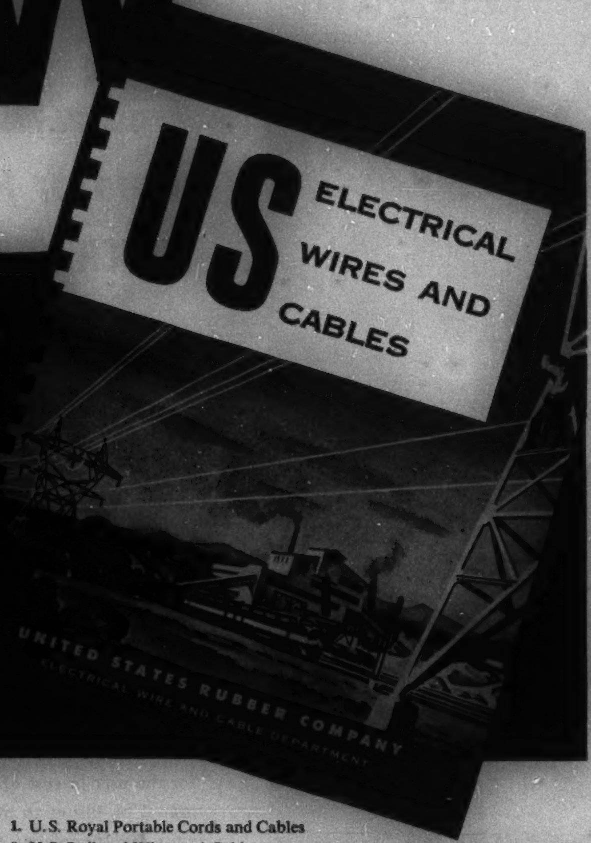
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A Redefinition of AIEE Membership Grades

C. W. FRANKLIN

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Recent amendments to the AIEE Constitution have changed the requirements for the various grades of membership. The chairman of the Board of Examiners explains in this article what these changes are and how applicants, sponsors, and references can help in making the system of admissions and transfer work smoothly and fairly.

RECENT CHANGES in the AIEE Constitution have augmented and clarified the qualifications for the several grades of Institute membership. A new grade, Affiliate, has been added, the Fellow grade has been made available by invitation only, and the qualifications for the grades of Associate Member and Member have been broadened and redefined. Engineering work in applications, construction, manufacturing, operation, and administration have been explicitly recognized in addition to design. Recognition is given to approved educational background and licensure in certain instances, but no essential barriers are erected on these bases. In some cases, minimum age and experience requirements have been changed. Altogether, the changes are extensive enough to require that all members be informed of them so that they may adjust their own personal plans for advancement accordingly and that they may discharge effectively their responsibility to their fellow members and the Institute when acting as sponsors or references.

As an aid to those who may not have followed the Constitutional changes in detail, Tables I-III present a comparison of the essential quantitative and qualitative requirements for membership prescribed by the present Constitution with those in effect up until July 1951. However, this brief review is not intended as a substitute for a careful reading of the pertinent sections of the Constitution and Bylaws by anyone preparing his own application, or acting as a sponsor or reference, or serving on the Membership or Transfers Committees. In certain special instances, the Constitution provides exceptions and equivalents and qualifications which have been omitted from the tabulations to give greater emphasis to the essential changes. Only the professional requirements for transfer or election are described; the privileges and obligations of the various membership grades are not covered.

WORK OF BOARD OF EXAMINERS

THE IMPORTANCE of membership in the AIEE, both to the individual candidate and to the Institute, is expressed by Section *14* of the Constitution which specifies that all elections and transfers must be by vote of the Board of Directors. To carry out this work, the Board of Examiners is delegated the responsibility of considering applications and recommending to the Board of Directors properly qualified applicants and candidates for transfer. The Examiners, consisting presently of 36 Fellows of the Institute, with a secretary on the Headquarters staff, meets monthly to consider in detail all proposals for transfer to the grades of Fellow and Member. The Examiners also consider individually all applications for election or transfer to other grades in which the secretary finds any doubt as to whether the requirements of the Constitution have been met. On the average, at every meeting of the Board of Examiners during the past 5 years more than 100 applications have received this individual attention in addition to the consideration given at many meetings to matters of general interpretation of the requirements which are raised by special cases or by questions from the membership.

To do its work effectively in the interests of all concerned, the Examiners must have the full and complete record as called for on the several application forms together with the informed and thoughtful comments of the sponsors and references for the candidates. This is especially true of Member transfers and applications, and Fellow proposals, where qualitative considerations play so large a part. The Examiners obviously cannot act favorably unless clear evidence is presented that the candidate meets the Constitutional requirements. The candidate or his sponsors are the only persons who can supply this information. Failure to supply it can result only in delay, as well as in costly and wasteful correspondence.

The need to supply adequate information to the Examiners is especially important in the case of transfer to Fellow grade for which application may not be made by the candidate. The sponsors of a Fellow candidate are required by the Bylaws to supply the Examiners with a full record of the professional work of the candidate and to indicate, as they alone can do, how he has "attained distinction" (Sections *4* and *11* of the Constitution). In addition, as specified by Section *2* of the Bylaws, they should supply a summary of the outstanding accomplish-

---

C. W. Franklin is with the Consolidated Edison Company of New York, Inc., New York, N. Y.

Table I. Comparison of New and Old Requirements for the Fellow Grade

Old Constitution (amended 7/25/51 and 7/23/52)	Present Constitution
Quantitative	**Quantitative**
Minimum age 32	Minimum age 40
Years as a Member* 5	Years as a Member* 10
Years active practice 10	Years active practice 15
Years in responsible charge 3	Years in responsible charge 5
References 5 Fellows	References 5 Fellows
Sponsors 5 Fellows	Sponsors 5 Fellows or Members
Qualitative	**Qualitative**
Sec. 3...Fellows and Members shall be entitled to a diploma...	*Sec. 3*...and when awarded the grade of Fellow shall receive a citation
Sec. 4 (a)...qualified to design and take responsible charge of important electrical work	*Sec. 4 (a)*...attained distinction in design, construction, manufacture or operation of important electrical work or products or in the teaching of a major course...
Sec. 4 (b). A professor shall have attained special distinction	
Sec. 4 (d). A person who has done notable original work...	*Sec. 4 (b)*...attained distinction by reason of inventions, original work...or as an engineering executive of...work of large scope, or the application of electricity to important engineering projects...
	Sec. 11. Fellow grade...shall be conferred...on those...whose outstanding work...is brought to the attention of the Board (of Directors) by five or more Fellows or Members who shall submit data...to substantiate the importance of the accomplishment and warrant the issuance of the citation . . .
Sec. 10...application may be made for admission to any grade of membership ...	Transfer to Fellow may not be obtained by application

---

* Consecutive years immediately prior to transfer.

Table II. Comparison of New and Old Requirements for the Member Grade

Old Constitution (amended 7/25/51 and 7/23/52)	Present Constitution
Quantitative	**Quantitative**
Minimum age 27	Minimum age 30
	Years as Associate Member* 2
Years active practice 5	Years active practice** 7
	Years responsible charge 2
References—4 Fellows or Members	References—5 Fellows or Members
Qualitative	**Qualitative**
	Sec. 5...7 years of active practice**...indicative of growth in competency and achievement...of a character satisfactory to the Board of Directors. In addition he shall be...
Sec. 5 (a). An electrical engineer by profession...under general direction ...shall have designed and taken responsibility for important electrical engineering work...	*Sec. 5 (a)*. An electrical engineer by profession...qualified in and have had responsible charge for at least 2 years of important electrical design, construction, manufacture or operation
or	or
Sec. 5 (b). A teacher...under general direction ...shall have taken responsibility for instruction...in a school of recognized standing	*Sec. 5 (b)*. A teacher of electrical engineering or electrical science...capable of teaching a major course..and...had responsible charge for at least 2 years of an electrical course in a school...approved by the Board
or	or
Sec. 5 (c). A person regularly employed in electrical or closely allied work...who by inventions or by proficiency in electrical science...arts ...or literature, or as an executive of an electrical enterprise of large scope . . . (is)...qualified to take responsible charge of the broader features of electrical engineering involved in the work under his direction	*Sec. 5 (c)*. A person working in the field...who by inventions, original work, or by proficiency in electrical science...arts...or literature, or as an engineering executive of an electrical enterprise of large scope or the application of electricity to engineering projects, has attained a standing equivalent to..."*a*" or "*b*"

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* Consecutive years immediately prior to transfer [except when applying on the basis of Section 5(d).]

** Credit 1 year for graduation from approved college curriculum. Credit 3 years for professional engineering license from approved authority.

ments of the candidate to be used in preparing the citation which the Constitution calls for to accompany the conferral of the grade. The five references can help greatly by addressing themselves to the substantiation of the outstanding accomplishments of the candidate.

Table III. Comparison of the Requirements for the New Grades of Associate Member and Affiliate With the Old Associate Grade

Old Constitution (amended 7/25/51 and 7/23/52) **Associate**	**Present Constitution** **Associate Member**
Quantitative	**Quantitative**
Minimum age 21	Minimum age 21
	Graduate of approved curriculum or
	Years of experience 5
References—3 Fellows, Members, or Associates	References—4 Fellows, Members, or Associate Members
Qualitative	**Qualitative**
An Associate...shall be either:	*Sec. 6*...the applicant shall be: (1) A graduate of an engineering curriculum that is approved by the Board of Directors or (2) if not...he shall have equivalent attainments including 5 years...of engineering experience...satisfactory to the Board of Directors...He shall be either: . . .
Sec. 6 (a). An electrical engineer by profession	*Sec. 6 (a).* An electrical engineer by profession...qualified under instruction and supervision to undertake electrical design, construction, manufacture or operation or
or	
Sec. 6 (b). A teacher of electrical subjects	*Sec. 6 (b).* A teacher of electrical subjects...under supervision teach subjects required in a curriculum approved by the Board of Directors
or	**Affiliate**
Sec. 6 (c). A person...qualified to fill a subordinate position in engineering work or...identified in a responsible capacity with an electrical enterprise	*Sec. 7.* An Affiliate...shall be at least 21 years of age...interested in rendering service to electrical engineering or electrical science in the fields of commerce, industry, law, science, or the arts, or...so connected with the applications of electricity that his admission as an Affiliate would contribute to the interests of the Institute
	References...3 Fellows, Members, Associate Members, or Affiliates

This procedure requires thoughtful effort on the part of at least five Fellows, the headquarters staff, the Examiners, and the Directors; as well as the Transfers Committee and others who may have had a part in identifying and submitting the candidate's qualifications. However, it is worth the work and time it takes because, in conferring the honor of the Fellow grade on a worthy Member, the Institute gains in prestige which is reflected throughout the membership.

FELLOW GRADE

UNDER THE amended Constitution, the Fellow grade is conferred by the Board of Directors on those who meet the new quantitative requirements outlined in Table I and who have "attained distinction" as a result of the importance, originality, or responsibility of their work. The sponsors of a candidate for the grade of Fellow are required to demonstrate that his work and his record are such that, when compared with others who meet the quantitative requirements, he can be rated as having achieved distinction. This may be done by submitting a complete record of the candidate's work and calling special attention to those parts in which outstanding accomplishment is indicated. A brief summary of the outstanding achievements then should be added to serve as a basis for the required citation.

MEMBER GRADE

THE PRESENT Constitution also has changed materially the quantitative requirements for attaining the grade of Member, and has amplified somewhat the qualitative requirement. For a comparison of the new and old requirements of this grade of membership, see Table II.

ASSOCIATE MEMBER AND AFFILIATE

TABLE III compares the old requirements for the Associate grade with the requirements for the present Associate Member grade and includes the essential qualifications for the new grade of Affiliate set up by Section 7 of the Constitution to provide for the type of member formerly covered by Section *6(c)* of the old Constitution. It should be noted here that graduates of curricula not approved by the Board of Directors (in the United States, those curricula not accredited by the Engineers' Council for Professional Development) may be accepted as Affiliates and subsequently may qualify for other grades when they have acquired the necessary experience.

IMPORTANCE OF COMPLETE DATA

IN REGARD to all membership applications, it has been the experience of the Board of Examiners over the years, and particularly since the changes in the Constitution outlined herein, that delay, misunderstanding, and perhaps disappointment to the applicants and sponsors of candidates have resulted from the submittal of incomplete records which do not do justice to the candidates for membership.

The members of the Board of Examiners cannot be presumed to know the candidates personally. Even where some do, it is clearly implied by the Bylaws that they must act upon the record as submitted since they themselves are prohibited from acting as sponsors or references.

It is especially important that the sponsors and references for Fellow candidates be explicit, clear, and specific in relating the records of their candidates to the Constitutional requirements.

SIGNIFICANCE OF MEMBERSHIP

SOME YEARS AGO the Transfers Committee set the objective: "Each member of the Institute in the highest grade for which he is qualified." All of the committees and officers of the Institute directly concerned have worked toward this objective and have made steady progress in its achievement.

Every member of the Institute has a personal stake in bringing about this result. It is important to each of us. not only that he personally hold the grade to which he is entitled, but that public acceptance of the meaning of the grade be confirmed by its uniform application to all members of equivalent professional standing. To describe an electrical engineer as "Member of the AIEE" should convey to the public a definite and accurate impression of a mature professional man qualified by experience and training to be in "responsible charge" of important electrical engineering work. In like manner, Student, Affiliate, Associate Member, and Fellow have significance in proportion to the degree to which all of the members have, by application or invitation, achieved their appropriate grades.

Thus, an important function of the Institute is the recognition of the experience and achievements of its members by appropriate grades of membership. It is the responsibility of each member to work for the attainment of "the highest grade for which he is qualified."

The Deductive Method in the Physical Sciences

HENRY MARGENAU

After pointing out the lack of attention paid to basic methodology in the United States until very recently, the inductive and deductive methods are discussed together with the correlational and theoretical approaches to scientific research. It also is indicated that the method of theoretical science can and should be applied to the social sciences.

THE POLITICAL AND economic maladjustments of the times are subjects of common knowledge and cause for universal concern. No less serious, however, is the cultural crisis that confronts mankind. It is manifest in divisive ideologies, in fragmentation of intellectual disciplines, and in the excessive specialization of scientific research. A cleavage has developed, not only between the arts or the humanities, on the one hand, and the sciences on the other; but even within the sciences a curtain seems to be condensing between the so-called physical and the social disciplines. Many believe that the method of the physical sciences is totally different from that employed in the social sciences, that it is this difference in method which accounts for the tremendous success of the former and the relatively slow progress of social institutions. Watchful scholars in both fields are asking: What is the mainspring for success in the physical sciences? Are their methods wholly unique, or are they transferable to other departments, particularly the field of human affairs? All these questions raise the important problem of methodology.

Concern for basic method is new in the United States. An all-prevading pragmatic spirit has kept its scientists busy with immediately profitable tasks. Interest in philosophy on the part of scientists has been frowned upon in view of the patent fact that it has kept some scientists from doing their best work. Results had to be achieved, and the less said about the way in which they were attained the better. Is it not true that a bird can fly without knowing the principles of aerodynamics? If a bumblebee studied the design of aircraft he would never venture to entrust himself to the air, for he would know that his ratio of wing surface to body weight is far too small for sustained flight.

Revised text of a conference paper, "The Development of Logical Deductive Disciplines in the Physical Sciences," presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Committee on Basic Sciences.

Dr. Henry Margenau is with the Sloane Physics Laboratory and department of philosophy, Yale University, New Haven, Conn.

All this is true, and it is good advice for birds and bumblebees. But suppose the art of flying is to be transferred from birds to men. When man wanted to fly he had to study hydrodynamics. Watching the birds was not sufficient for this task. A conscious effort was required to study the phenomenon of flight and to formulate the laws which regulate them. And so it would seem to be if the method of the physical sciences is to be made useful for an understanding of human behavior. More must be known of these methods than their mere use in the physical sciences demands. The physicist, the chemist, and the astronomer, each must become reflective and ponder over the meaning and the foundation of his own discipline.

SCIENCE AS INDUCTIVE QUEST FOR USEFUL KNOWLEDGE

Physical science is sometimes regarded as a great mass of inductive activity. This inductive activity is understood to be the enterprise of carefully collecting, comparing, sifting, and cataloging facts with a zeal and an honesty characteristic of the scientific worker. This limited view, however, ignores some of the theoretical or ideal elements which are always present within true scientific understanding. It underestimates the use of reason as well as the illuminating connections which this faculty provides among facts inductively discovered. If science were nothing more than induction, it merely would move from discovery to collation and tabulation, ending with a statement of regularities gleaned by an inspection of tabulated facts. Scientific knowledge then would be a surface texture of incidental observations loosely joined together and devoid of the solid ground of logical relations into which the roots of the facts always extend. The view which regards science as nothing more than an inductive undertaking in the Baconian sense is one-sided, limited, and incapable of sufficient generalization. Unfortunately it is quite common in the social field and may be responsible in part for the separation between the science of nature and that of society.

CORRELATIONAL VERSUS THEORETICAL SCIENCE

Surveying the entire domain of scholarly endeavor called science, two large areas can be distinguished roughly. One will be called, for want of a better name, correlational science, and the other may be called theoretical science. The distinction is not clear cut; there are many disciplines which fall partly in one and partly into the other of these two categories. By correlational science is meant one which remains largely on the primary ground of observed facts, which describes, orders, and judges these facts, and exhausts itself in establishing correlations between them. Researchers in these fields often pride themselves upon their independence of theories, which to them are odious things that ought to be avoided. They draw inferences from their observed facts and announce their conclusions with probability, spurning the certainty which flows from the basic theoretical understanding they deem illusory.

The theoretical scientist, on the other hand, links observed facts with concepts which often depart widely from the immediately sensed. These concepts, ideas, or constructs take on greater and greater reality and importance as they enter into more extensive connections with observed facts. Modern physics is a theoretical science, as indeed it must be if it is to deal with the unobservable entities of the atomic realm. Knowledge of electrons springs largely from abstract principles which are not obtained altogether by induction, but which are nevertheless checked in a more indirect way against the facts of observation. Among the sciences which are largely theoretical, and therefore called exact, are applied mathematics, physics, astronomy, and much of chemistry. Predominantly correlational sciences are botany, zoology, and large parts of both sociology and medicine. Some sciences might be said to be intermediate between these two classes; these include psychology, genetics, economics, and many phases of engineering.

The distinction just drawn is a time-bound one; it describes merely a given stage of a science. The history of science shows that all branches of it passed through a formative stage in which they were descriptive, that is, correlational. This stage is then followed by a theoretic one. Physics, for instance, was correlational in the days of Aristotle and attained exact or deductive status in Galileo's and Newton's day. Biology is in the process of transition at the present time. It well may be that all correlational sciences are on the way toward becoming theoretic in the end. This is a conjecture which obviously cannot be proved. To clarify the meaning of the distinction made, it seems well to study in slightly more detail the process of deduction.

THE PROCESS OF DEDUCTION

To reason deductively means to draw conclusions from premises, not from incidental facts. The simplest example of the deductive process is the syllogism, typified by the time-honored example, "All men are mortal, Socrates is a man, therefore Socrates is mortal." To use a more modern version, every arithmetical operation leading to a computed result is a deduction, the conclusion being already implied in the postulates constituting the meaning of number. More interesting perhaps is the kind of deduction often employed in modern electrical engineering. Here it is possible to start, for example, with Maxwell's equations, use them together with boundary conditions to compute the modes of electromagnetic waves which can be transmitted by wave guides. By purely mathematical operations, predictions can be made with respect to actual occurrences, and the labor involved in making these predictions is often far less than the work of direct experimentation. On many occasions, of course, such a deductive process is not available. There exists no general principle which can guide the engineer in a search for materials having specified properties. However, when deductive methods are available, they are usually time-saving, powerful, and elegant.

There was a time when the use of deductive method in science was under suspicion, and the effects of this attitude still are being suffered. Naturally deduction must start with premises, and the conclusions drawn are never truer than the premises themselves. But where do the premises come from, and who vouches for their truth? Philosophers of the rationalist school have held them to be self-evident, have called them axioms, and the term axiom carried with it an assurance of indubitability. It was thought at one time that the postulates of Euclidian geometry were axioms of indubitable truth and that the consequences following from them must be equally valid. This conviction received a rude shock, however, when the existence and plausibility of non-Euclidian geometries was discovered during the middle of the last century. What seemed at one time absolutely certain was suddenly not only drawn into question, but actually proved to be false. This experience and many others recorded in the history of science, constitute an indictment of the absolute truth of premises and has brought to the deductive method a measure of disrepute. Scientists sometimes have felt that, if the premises are never certain, the conclusions are not interesting at all and, therefore, have rejected all rationalistic elements in science.

The lesson with respect to the fallibility of premises used in deductions is an important one and always must be remembered. However, the process of deduction is not tied to infallible premises. The premises, axioms, or postulates which it does employ can be regarded, and are regarded in all proper applications, as tentatively true. Their value does not lie in being certain about them, but in being able to derive from them specific consequences which can be tested against experience. The verification of these observational experiences reflects back on the certainty of the premises, and when there are sufficiently many instances of verification the premises are said to be "true." It is in this way that faith in Maxwell's equations has grown to a complete acceptance of this theoretical formalism. Let it be noted that Maxwell's equations cannot be derived from experimental facts, no matter how numerous and convincing they are as individual instances. Such equations imply more than any finite body of experimental information, and herein lies their power. Herein also lies their capability of being wrong.

THE METHOD OF THEORETICAL SCIENCE

THE METHOD OF THEORETICAL SCIENCE is an interplay between induction and deduction. Postulates are suggested by experimental facts, and experimental facts are in turn deduced from postulates. These postulates, although not a priori true, gain stature and validity as the process of experimental verification succeeds. Space does not permit a complete description of this process here; hence attention is drawn to a more extensive account of it elsewhere.[1]

OPERATIONAL VERSUS CONSTITUTIVE DEFINITION

THE DUAL ASPECT OF scientific method here introduced has an important bearing on the problem of definitions in science. These must be of two kinds, one called operational, and the other constitutive. An operational definition provides an access to theoretical constructs from the domain of observational facts; the constitutive definition connects theoretical constructs by logical rules and mathematical relations among themselves. A scientific quantity which is only operationally defined is devoid of logical implications and permits no reasoning about it, a quantity which has only a constitutive definition is experimentally sterile and leads to nothing more than speculation.[2]

ADEQUACY OF THE THEORETICAL SCIENTIFIC METHOD TO HUMAN AFFAIRS

TO RETURN TO the problem raised in the beginning, scientific method, to be applicable and successful in the field of human affairs, must emphasize equally both poles, induction as well as deduction. It is not to be expected that the present overemphasis on the inductive will lead to successes in the human field comparable to those in the physical sciences, which do emphasize both aspects of method in well-balanced fashion.

It is often asserted that the description of social interactions never will be scientific in the sense of physics. This view allegedly gains plausibility from two circumstances: one, the complexity of social phenomena, which is supposed to be far greater than that in the physical world, and two, the reputed impossibility of isolating variables. Neither of these destroys the applicability of scientific method in its fullness to social science. As to complexity, physical science also showed a welter of unrelated and confusing facts before the light of deductive method shone through its structure. The second argument which claims that a measurement in the social sciences interferes very strongly with the situation to be measured, can be refuted by pointing to the modern quantum theory of physics, which does in fact provide a deductive formalism dealing with the situation in which the interaction between an observation and the physical system to be observed is extreme.

REFERENCES

1. The Nature of Physical Reality (book), **Henry Margenau.** McGraw-Hill Book Company, New York, N. Y., 1950.

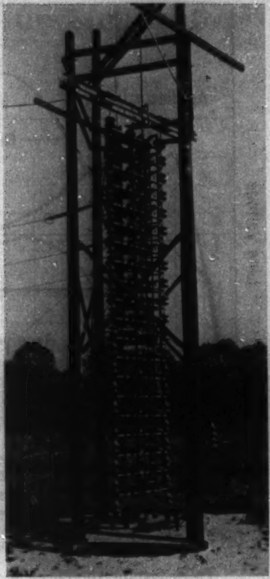
2. Ibid. Chapter 12.

Oak Ridge Cyclotron to Open New Field in Nuclear Physics

A new cyclotron has been developed at Oak Ridge National Laboratory, Oak Ridge, Tenn., which is said to open a whole new field of fundamental research in nuclear physics. The cyclotron is a 63-inch type designed to accelerate heavier elements.

In heavy-particle acceleration, according to the Union Carbide and Carbon Corporation which operates the laboratory for the Atomic Energy Commission, nitrogen ions are accelerated to an energy of 25,000,000 electron volts. This energy makes it possible to bring about nuclear fusion of elements. More specifically, nitrogen nuclei are forced to combine with nuclei of such elements as oxygen and carbon to form the heavier nuclei of fluorine, sodium, and aluminum.

Field Surge Testing of Extra-High-Voltage Lines



PHILIP SPORN
FELLOW AIEE

A. C. MONTEITH
FELLOW AIEE

Artificial lightning tests are now in progress on highly insulated experimental transmission lines with the chief objective of acquiring extra-high-voltage data. However, the test program anticipates the use of the equipment to obtain similar data applicable to lower voltage lines.

HIGHER TRANSMISSION VOLTAGES have created a need for experimental surge data. The incremental cost of extra-high-voltage equipment calls for careful co-ordination of lightning arrester characteristics and equipment insulation in order to maintain the lowest practical margin between protective levels and insulation levels. Surge characteristics at voltages at which corona is important are fundamental to this consideration.

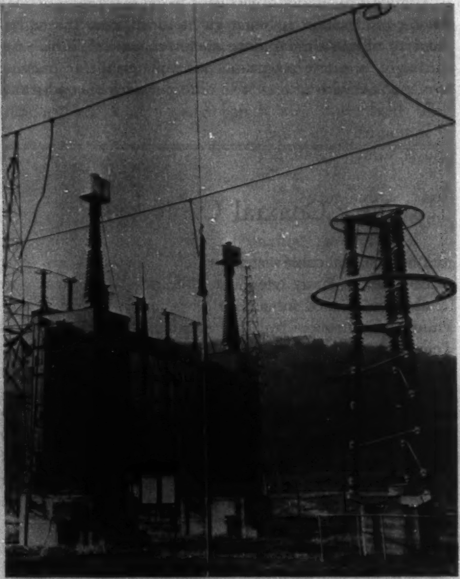


Figure 1. View of the substation showing the voltage divider in the center foreground. The two transformers shown were used in the earlier 60-cycle corona and radio-influence tests

The highly insulated experimental lines of the American Gas and Electric Company at Brilliant, Ohio,* are ideally suited to the gathering of such data. Not only are there transformers and lightning arresters at the site, see Figure 1, but the transmission lines are strung with conductors of the diameter and type that will be used in extra-high-voltage transmission. In addition, the high-voltage substation is typical with respect to spacing of conductors, and the presence of open stub busses that could cause doubling of surge voltages.

Recognizing the excellent opportunity afforded by this experimental equipment, the American Gas and Electric Company and the Westinghouse Electric Corporation have undertaken a lightning test program. The objectives of the full-scale surge tests that are now under way in this field laboratory are

1. To determine the attentuation of surge voltages that travel along the line.
2. To determine the slope of these travelling wavefronts.
3. To determine voltage coupling factors.
4. To determine the influence of line conductor attenuation, in conjunction with various combinations of substation equipment, on the selection of substation insulation levels.

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* The same lines that were used for the determination of 60-cycle corona-loss and radio-influence characteristics in earlier tests.

Philip Sporn is president of the American Gas and Electric Company, New York, N. Y., and A. C. Monteith is vice-president in charge of engineering of Westinghouse Electric Corporation, Pittsburgh, Pa.

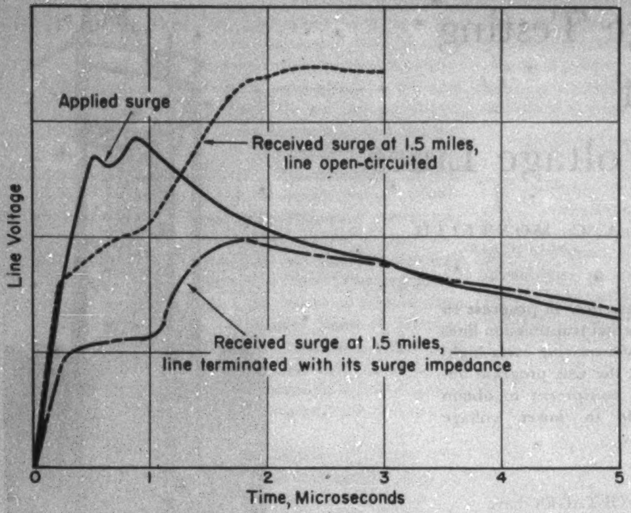

Figure 2. Typical replot of cathode-ray oscillograms. The solid curve shows the surge applied at one end of the 1.5-mile line. The other two waveforms are those of the surge as received at the other end of the line, one with the line open-circuited, and one with the line terminated with its surge impedance. These curves show the effect of attenuation and wave distortion as the surge travelled the 1.5 miles

5. To determine the effect of several lines entering the station on the lightning voltage in the station.

6. To determine the most effective location of lightning arresters with respect to the remainder of the substation equipment.

Westinghouse supplied a 2,000-kv surge generator that has been erected at the open end of the two 1.5-mile lines, farthest from the substation. See title picture. It uses the Marx circuit and consists of 20 capacitor stages in series with each stage comprised of two 50-kv capacitors. It is mounted on four poles and can deliver into one conductor of a transmission line either positive or negative surges of approximately 1,800-kv crest value, 0.6-microsecond front, and 7 microseconds to half magnitude. The surge can be applied to any one conductor, or any combination of conductors.

Of the two 3-phase lines available, one is strung with 1.65-inch Hedernheim copper, and the other with 2-inch expanded steel-reinforced aluminum cable. Both lines are insulated beyond the level required for the highest transmission voltages considered to date.

The two hot-cathode Du Mont cathode-ray oscillographs being used have photographic equipment capable of a writing speed of about 1,000 miles per second, thus making it possible to record the fastest wavefronts. The oscillographs are coupled to the lines, or station bus, with specially designed voltage dividers that have low burdens and small distortion.

One oscillograph located near the surge generator records the applied surges. The other is portable, and is used to measure the voltages at any point on either line, or at any point within the substation. Terminating resistors are available to simulate approximately infinitely long lines.

Much valuable data have been collected from the active testing over the past few months. See Figure 2. It is expected that several more months of field work will be required to complete the tests.

Although the major objective is to get extra-high-voltage data, consideration is being given to utilizing the equipment to obtain similar data on lower voltage lines. Accordingly, the test program contemplates the restringing of one phase with at least two different sizes of conductors.

New Coaxial Cable System

A new coaxial cable system, which is capable of providing three times as many telephone circuits as the system now in use, was opened for service recently on the New York–Philadelphia route by the American Telephone and Telegraph Company.

An existing cable along the route has been equipped with the new system, known as *L-3* Carrier, increasing the capacity of the cable. The new system makes it possible for one pair of coaxial tubes to carry as many as 1,800 telephone conversations simultaneously. It can be used also for television transmission. A pair of coaxials can carry a television program in each direction together with 600 telephone conversations.

Initially, 260 circuits have been placed in service between Newark, N. J., and Philadelphia, Pa. Eleven new repeater stations were built midway between existing stations so that repeaters are now located at approximately 4-mile intervals along the route.

Amplidyne Voltage Regulator for Turbine Generators

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THE USE AND DEVELOPMENT of voltage regulators over the past 50 years has produced the modern amplidyne voltage regulator. This regulator includes a voltage-sensitive circuit composed of static elements, such as transformers, reactors, resistors, capacitors, and metallic rectifiers. These are all reliable, conservatively designed components with long life expectancy. The voltage-sensitive circuit controls the voltage introduced by a rotating amplifier, called an amplidyne, into the shunt field circuit of the self-excited exciter for a large turbine generator. The regulator controls exciter voltage, by varying the amplidyne voltage to aid or oppose the flow of current through the exciter shunt field, to maintain the generator terminal voltage essentially constant. A minimum excitation limit circuit is employed to guard against reduction of generator excitation below values which will safely avoid loss of synchronism. This limit circuit responds to generator underexcited reactive current, and it can be adjusted to allow larger values of this current at low kilowatt loads than at high kilowatt loads. The limit circuit is composed of static components similar to those used in the voltage-sensitive circuit.

The voltage-sensitive and limit circuits are housed in a floor-mounted enclosure with the auxiliary control equipment. A typical unit is shown in Figure 1. The amplidyne is installed in an associated enclosure, or in a separate location; it is supplied on a base and coupled to an induction-type driving motor. The regulator is designed as a standardized factory engineered and assembled unit requiring a minimum of installation planning and effort.

Figure 1. Typical regulator and auxiliary equipment

The amplidyne regulator provides corrective action proportional to variations in generator voltage from the desired value. It is capable of holding voltage within a 1 per cent band, or less, over the full load range of the generator. Transient performance is shown in Figure 2 which indicates the relatively large corrective action in terms of amplidyne voltage applied by the regulator in a fraction of a second, which occurs as a result of only a small deviation of the generator voltage.

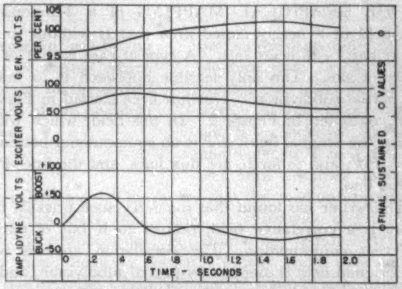

Figure 2. Transient performance of amplidyne regulator with 25,000-kw, 60-cycle turbine generator with 250-volt exciter (American Standards Association response = 0.5) and 250-volt amplidyne following approximately $3^1/_2$ per cent increase of set value of voltage held by regulator. Generator operating with terminals open circuited

Chief features of the amplidyne regulator are that it

1. Provides accurate, continuously acting no "dead band" voltage regulation and rapid smooth operation.
2. Permits close division of reactive current between machines and good system reactive control.
3. Extends the machine steady-state stability limit, permitting the use of lower short-circuit ratio generators, or higher external system reactances, or permitting larger underexcited reactive loading.
4. Permits safe underexcited operation with the reactive ampere lower limit.
5. Offers excellent reliability with little maintenance.
6. Increases reliability by eliminating the pilot exciter from the main generator shaft.
7. Is flexible enough to permit the use of a standardized design with almost any type of rotating exciter.

Tests and analytical studies have shown the amplidyne regulator to be suitable for all applications with the possible exception of those involving very special requirements. (The regulator may be used with any of the usual types of rotating exciter excitation systems; no special exciter design requirements exist.) Its general suitability has been shown by its wide application on small power systems, as well as by its use on the great majority of the largest power systems in the United States. These applications already have produced approximately 300 machine-years of amplidyne regulator service.

Digest of paper **52-229**, "Development of a Modern Amplidyne Voltage Regulator for Large Turbine Generators," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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A New Property of 2-Dimensional Fields

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THE GRAPHICAL MAPPING of a 2-dimensional field in a nearly closed area that is without sources is, at best, a difficult task. A typical case is that of flux down a slot. The only feasible approach is to map it by partial subdivision. This has been started in Figure 1 and continued in Figure 2. In this field, which will be called the original field, *A′P* is an equipotential boundary; *AA′*, *BB′*, and so forth, are flux lines, and the line *A″P* is a flux line.

The writer has found that for every such original field, there is a correlative field, related to it but of entirely different conformation. The correlation appears when the original field is mapped by partial subdivision, and the correlative field is mapped by regular subdivision.

The correlative field for this case is shown in Figure 3. The boundary and the central line are retained; but whereas, in the original field they had different meanings (equipotential and flux) they now have the same meaning. That is, *H′P* and *H″P* are now both to become equipotential lines, or else both to become flux or flow lines.

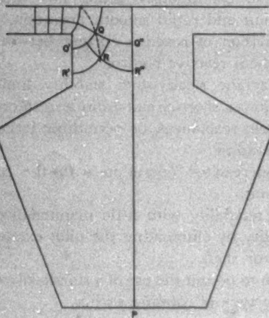

Figure 1. Map started in the high-strength region

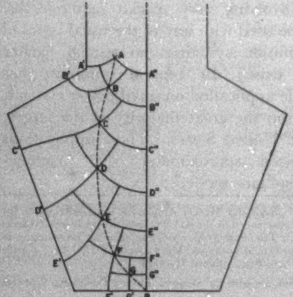

Figure 2. The original field, mapped by partial subdivision

The correlative field might, for example, be set up by cutting out a shape as shown, from a uniformly conducting sheet; attaching an electrode across the slot mouth at the top; another small electrode at *P;* and setting up the generally vertical current flow lines as shown. If this correlative field is mapped by regular subdivision, *HP* is the midline: half the current flow is on either side of it.

Going back to the original field, Figure 2, we may add the dashed bisector line *AP*, a line which bisects the corner angles of all the curvilinear squares through which it passes.

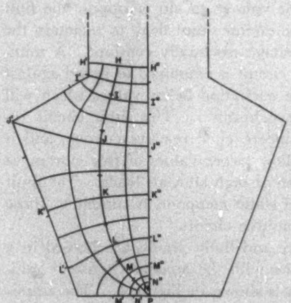

Figure 3. The correlative field, mapped by regular subdivision

The writer has proved that the midline of the correlative field is identical with the bisector line of the original field. Moreover, certain factors of relationship have been worked out, whereby the correlative field can be made to tell the locations of starts of pairs *A*, *B*, *C*, and so forth, in Figure 2, and where to land these pairs, as at *A′* and *A″*, *B′* and *B″*, *C′* and *C″*, and so forth.

Thus, if the correlative field is mapped first, the original field can be derived from it. The correlative field is always quite easy to map, as compared with any direct attempt to map the original field. To map by this 2-stage process, and achieve the same good degree of accuracy, takes perhaps one-fifth the time it would take to map the original by direct-attempt methods.

This correlative property was recently discovered while working with map sketches at the blackboard, and then tested on a number of cases. A general proof was then worked up. Since it seemed improbable that a new property of fields would be discovered at this late date, it was submitted to quite a number who work with fields, in mathematics, physics, and engineering. It turns out to have been unknown to all who have seen it.

Digest of paper 52-240, "A New Property of 2-Dimensional Fields," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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UNIVAC on Election Night

A. F. DRAPER

A discussion of UNIVAC's role in predicting the national election results is presented which includes the development of a mathematical theory as well as the actual setup of the problem on the machine.

THE DEBUT OF UNIVAC to the largest television audience that has ever existed took place on election night, November 4, 1952. Various newspaper writers have expounded at great length on the injustice done to UNIVAC and how undoubtedly its feelings were hurt. Therefore, a public apology is being made to UNIVAC in the hope that it will not build up a neurosis that will interfere with its work for the Atomic Energy Commission (AEC).

There are at present six UNIVAC's in operation. Number *5*, which now belongs to the AEC, was the one shown on television, see Figure 1; but Number *4*, also an AEC machine, was used to check the data for reasonableness, and Number *1* was all ready to take over at a moment's notice in case Number *5* failed to operate satisfactorily.

Essentially, there were two parts to the problem. The first of these was the development of a mathematical theory that would make an election prediction possible; and the second, of course, was the actual setup and running of the problem on the machine as the returns started to come in.

When the possibility of handling this problem was first discussed some 6 months before the election, it was assumed that such a calculation was possible and that UNIVAC would be able to perform the necessary calculations. At that time past trends were investigated and the whole country was separated into political subdivisions that could be segregated best in accordance with past voting habits. As time began to run out, it was recognized that the problem was getting bigger and bigger, and Dr. Woodbury, Associate Professor of Statistics at the University of Pennsylvania, was called in to work with Dr. Mitchell, head of the UNIVAC Applications Department. It was realized at this time that there was not even a vague formula for prediction that could be applied, and the mathematical group with Dr. Woodbury set out to develop a theory and put this into practical mathematics. This was an exceedingly complicated assignment in an almost entirely new field. There was some mathematical theory obtainable from the Gallup poll studies and this was used as far as it went. It is now known that this work was accomplished correctly to a degree far beyond the initial hopes of the people who worked it out.

What was seen on television was only a small part of the actual work that the UNIVAC did. It was desired to predict the probability of the outcome state by state and the expected majority in each state. As this alone would not be conclusive, possible final votes at 3 to 1 and 10 to 1 odds in either direction were calculated. This means that the machine produced a working sheet that would be extremely useful to a political commentator in estimating trends. At the same time, however, essentially this same information was put into the UNIVAC and it computed a national prediction which included the number of states for each candidate, the total electoral vote for each, the total popular vote for each, and the relative chances that each candidate had of winning. The electoral vote also was figured at 3 to 1 and 10 to 1 odds in either direction. Here possible evidence of the first mistake may be noted. Good information that would interest a statistician and would be useful to a statistician in making up his own mind was being provided. This was probably a mistake because what really was wanted was the final answer and the machine proved, in the first run, that it also could give the final answer far better than experts reading a super sheet of probability figures.

Courtesy Columbia Broadcasting System

Figure 1. UNIVAC during a test run prior to its use on election night. Walter Cronkite (right) and UNIVAC's coinventor J. P. Eckert (center) consult the data which are printed automatically by the printer (foreground). The operator (left) only directs questions to UNIVAC

The setup election night deserves some note because there surely never has been a time before when so much computer capacity was assembled and used on a problem

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Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Committee on Computing Devices.

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of this kind. The actual returns were sent into Philadelphia by Teletype immediately on receipt at the Columbia Broadcasting System newsroom in New York. These returns were immediately transcribed in triplicate on magnetic tape. Due to the time scale involved, two operators were assigned to each of the three Unitypers and one checked while the other typed. These three duplicate tapes were then put on three Uniservos under control of UNIVAC Number *4* and were checked at a rate of 13,000 alpha numeric characters per second to be sure they agreed. At the same time, a fourth tape was generated taking out all possible disagreements. During this run, UNIVAC also sorted the returns into a prescribed sequence. These sorted returns were then screened by the UNIVAC for unreasonable data. Three actual checks were made:

1. The number of precincts reported was compared with the total number in the area concerned.
2. The reported vote was required to be at least as great as the last report from that particular area.
3. The reported vote per precinct was compared with a high and low value computed beforehand from the 1944 and 1948 returns data.

All this work produced an output reel, with every possible accuracy devised, that was then put on Machine Number *5* as the input for the actual prediction run. In the attempt to be sure that the figures were accurate, there was one point of accuracy that was not covered. The transmission by Teletype produced one noticeable error—again human—when somehow or other the Democratic and Republican votes for the state of Massachusetts got mislabeled and UNIVAC, therefore, predicted a Democratic instead of Republican win in Massachusetts.

The prediction run itself was rather complicated. No other computer in existence could have handled or attempted it. UNIVAC was only able to do it because of its ability to handle really large volumes of data fast. The actual computation could have been done on other computers, but the volume of data that had to be handled would have been too great for them. UNIVAC's ability to handle the alphabet normally at the same rate of speed was necessary in this work. Also without the complete self-checking that is built into the UNIVAC, there surely would have been so much more worrying about the results of computation that an even worse performance would have resulted.

The actual mechanics performed by the machine to make the over-all national prediction are interesting. To start with, all the information on the returns of 1944 and 1948 were set up to be on call in the machine. In addition to this, a complete analysis of the voting behavior all the way back to 1928 was put into the machine. This analysis set up patterns on the basis of the fixed vote and the so-called variable or independent vote. Such a complete analysis never before had been set up for an election night prediction because before it never had been possible to handle the mathematics involved, and apply such an analysis in a reasonable length of time.

As the returns were fed into the machine, they were compared against these back data and the machine selected the closest possible pattern based on the probabilities of the past returns. This pattern was then used to predict the whole election, but only as a working stage and not as a final prediction. Having selected the whole pattern, the machine then adjusted the pattern to take into account any differences between the actual returns and the pattern it had selected. From this adjustment, the machine predicted final percentages for all the different states and the subdivisions such as New York City, Chicago, and other areas which were separated from the state votes and treated separately because of recognized differences in voting behavior. These percentages were given as a per cent of Democratic vote. In fact, all results were worked on a percentage of Democratic vote basis, which is customary in this work because "D" comes before "R" in the alphabet.

Once these percentages were obtained, the machine then figured the probabilities of a Democratic or Republican win based on these percentages. To most people, the percentages would seem to give the answer, but actually the percentage must be treated as a probability only. For example, 53 per cent of the vote for a candidate in a certain state may mean only that that candidate has a 5 to 2 probability of winning, and the 2 chance for the opposing candidate cannot be overlooked in the whole; if six states had odds of 2 to 1, it would not mean that there were six states for the one candidate, but that the true relationship was actually 4 to 2.

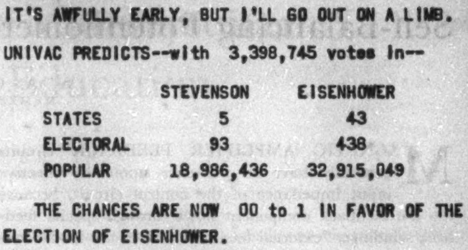
The machine then computed the probability of its being wrong, and this was taken into account later in the final prediction. Having computed all the probabilities by states, these were then assembled into a 531-degree polynomial which was solved to get the probability distributed. Of course, 531 is the number of electoral votes. The solution of this 531-degree polynomial was the most time-consuming job in the process. The whole run on the machine from entry of data to final prediction took about 6 minutes including this polynomial.

After calculation, the output of the machine for the national prediction, in which most people were interested, was then given in the form of states for each candidate, the electoral vote for each candidate, and the estimated popular vote for each candidate. The machine also gave the odds in favor of that candidate. These odds were programmed up to 100 to 1. Anything over 100 to 1 would print only as two zeros (00) because no one had envisioned the possibility of the machine computing greater odds until the election essentially was over. At 8:30 p.m. on election night, slightly over 3,000,000 scattered returns were in, largely from eastern states. These were put into the machine and following the procedure outlined before, the machine actually figured from the trend factors complete returns for all states including 21 states from which no returns at all had been received. The prediction that the machine turned out is a matter of history, but Figure 2 is included to show the actual machine output. Note that the chances read 00 to 1 in favor of the election of Eisenhower. This means that the odds, according to the machine, were greater than 100 to

1 that Eisenhower would be elected by the greatest landslide in history. Previous to this election, the greatest landslide was the Hoover election in 1928.

You will realize that this prediction posed a very definite problem. First, everyone was expecting a close election; second, there were so few votes counted that it was beyond comprehension that the machine could predict with such a degree of certainty that the odds would be greater than 100 to 1. As no one had been able to attempt such a mathematical analysis before, and as it was impossible to check by human calculation within a reasonable time in years that such a calculation could be made, it just was not understood how the odds could be so heavily in favor of General Eisenhower. In addition, you probably can imagine the consternation when the machine predicted an Eisenhower win in a good many southern states. Coupled to this was the fact that there were practically no returns from the states in the South that the UNIVAC gave to Eisenhower.

The natural first human assumption was that something was wrong in the programming, and therefore this prediction was not broadcast. There immediately followed a tense period in which everything was done to locate possible programming errors. As none was found, it was decided to change artificially the factor that expanded the small number of returns received into the estimates of total votes for each state. Remember that it was this factor only that predicted the complete vote for the 21 states that had not reported as well as the great majority of votes in the states from which there were only a few returns. It is very easy to change this factor in UNIVAC by running the program to a breakpoint where this factor is computed and then changing the factor by typing in the new figure from the supervisory control. Change in this factor could not make the machine predict a Stevenson victory. However, it was changed enough to make the election look close on the basis of the returns received at that time. Due to the time factor, this close prediction was put on the air, but 10 minutes later the mistake was realized. In spite of the factor change, the trend was so evident in the next set of returns processed that the machine swung back again to the Eisenhower landslide. Then it was clear that there was no problem: the machine was right, and it was permitted to go back to its own calculation of the proper figures.



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IT'S AWFULLY EARLY, BUT I'LL GO OUT ON A LIMB.
UNIVAC PREDICTS--with  3,398,745 votes in--

                    STEVENSON      EISENHOWER
  STATES                5              43
  ELECTORAL            93             438
  POPULAR          18,986,436     32,915,049

  THE CHANCES ARE NOW  00 to 1 IN FAVOR OF THE
ELECTION OF EISENHOWER.
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Figure 2. UNIVAC's first actual output on election night at 8:30 p.m.

Looking back now, it is very easy to see the human mistakes. There have been five major occasions of extreme importance when UNIVAC's correctness was doubted. In every single one of these instances UNIVAC was right, and "we poor humans" were wrong. These other times should have been remembered election night, and the supposedly certain knowledge that this was to be a close election and that southern states vote Democratic should have been disregarded.

Perhaps, however, these mistakes can be useful in providing a moral:

"Don't THINK, let UNIVAC do it for you!"

Electronic Control Device Provides Remote Control Computer Operation

A new electronic device, the model *R5 GEDA* recorder, has been developed at Goodyear Aircraft Corporation. Specifically designed for use with analogue computer systems it provides remote operation of computer systems by built-in control units, and features excellent stability and frequency response. Six channels of recording are provided either in curvilinear co-ordinates (ink pens) or rectilinear co-ordinates (hot wire pens). The operator at the desk-type console determines the choice of pens. Coefficient potentiometers may be provided for connection to the computer so that the operator need not leave the recorder for many runs that differ only in the values of one or two coefficients or initial conditions.

Six d-c amplifiers feature calibrated gain controls and negligible drift. The accuracy is limited only by the linearities of the pen motors. The balance control may be used to offset input signals in an amount equivalent to four times the full-scale deflection without distortion.

Self-Balancing Potentiometer-Type Magnetic Amplifiers

W. A. GEYGER
MEMBER AIEE

MAGNETIC AMPLIFIER FEEDBACK circuits generally have no influence upon the effective input impedance of the control circuit, because the d-c feedback component flows through special feedback windings, "external feedback," or in the load windings, "internal feedback" or "self-saturation." Therefore, the effective impedance of the control circuit is determined solely by the actual total resistance of this circuit comprising the resistance of the control windings and a series resistor which is conventionally provided to increase the speed of response of the magnetic amplifier.

Feedback arrangements which do not influence the effective impedance of the control circuit are characterized by the fact that the winding components producing the feedback effects are inductively coupled with the control winding components. These arrangements may be termed "pseudo-feedback circuits," because they do not have the inherent property of influencing the actual magnitude of the input circuit impedance, such as, for example, the electronic amplifier of the cathode follower type does.

However, it is important to note that "real feedback" can be applied to magnetic amplifiers, particularly for instrumentation purposes, by feeding back a voltage or current, proportional to the actual load current, resistance-coupled into the control circuit loop to obtain a large amount of degeneration. This arrangement, preferably employing a magnetic amplifier of the balance detector type, Figure 1, will have inherent self-balancing potentiometer characteristics, because fulfillment of balance conditions in the control circuit can be obtained by means of a special compound feedback circuit: positive external or internal feedback produces an effectively infinite gain that is highly degenerated by negative feedback resistance-coupled into the control circuit loop. Thus, in the case of voltage as well as current input, the balanced control circuit demands practically no energy from the input source. Indeed, the effective input resistance of a self-balancing magnetic amplifier for voltage measurements is about 100 to 1,000 times higher than the actual input circuit loop resistance; and the effective input resistance of a self-balancing magnetic amplifier for current measurements is about 100 to 1,000 times smaller than the actual resistance of the control windings.

The unique feature of a considerably reduced control current for the entire working range means a materially more linear relationship between the input and output quantities. Over certain ranges large variations in supply voltage, supply frequency, load resistance, and control circuit resistance have a comparatively small effect upon the "transconductance," "voltage ratio," "current ratio," or "transresistance" of self-balancing magnetic amplifiers operating under extremely stable conditions with a high over-all power gain. For certain applications special compensating effects can be applied by designing the degeneration network in such a way that resistance values of this network are a function of voltage, current, temperature, or time—derivative feedback effects such as delayed degenerative feedback.

Results of various measurements lead to the conclusion that the actual behavior of self-balancing magnetic amplifiers approximates very closely corresponding characteristics of an "ideal amplifier," just as an electronic amplifier of the compound feedback type does.

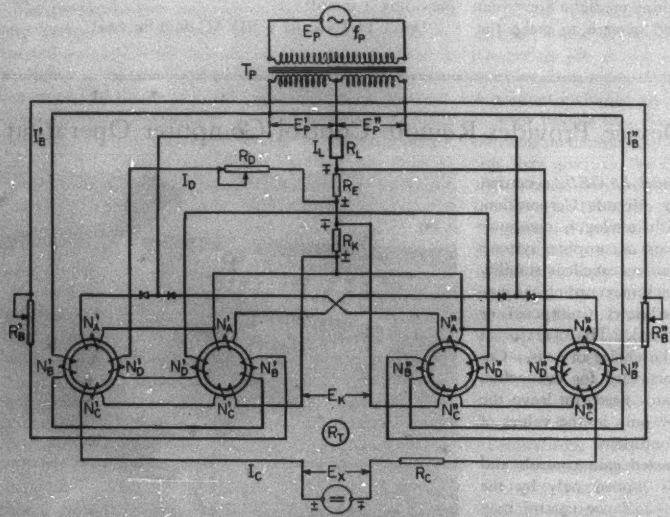

Figure 1. Self-balancing magnetic amplifier of the self-saturation push-pull d-c load type for voltage measurements

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Digest of paper 52-271, "Magnetic Amplifiers of the Self-Balancing Potentiometer Type," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The Equipment Manufacturer and Power Education

H. N. MULLER, JR.
FELLOW AIEE

Possibilities for stimulating professional work still exist and are increasing for the young man who chooses work in the power field. Manufacturers and employers whose interests lie in this field should stress management positions and new developments in power generation, sources of power, high-voltage transmission, and distribution as great opportunities for young engineers.

DISCUSSING THE field of power engineering in the electrical manufacturing industry is not a novel experience these days. Since World War II, a great deal of frank discussion, objective selling, and even promotion (however dignified in nature) has been necessary to keep power education in electrical engineering alive and active in America. Even then the number of young men following this path of study has been disappointing and definitely inadequate.

The most unfortunate aspect of this situation, reflecting paucity in numbers preparing for such a necessary element of our economy, is that it is basically undeserved. One cannot name a major field of technical endeavor where the long-range opportunities are greater. Stress must be given to the words "long range," and for this reason. Our country has produced certain glamour industries, either conceived or accentuated (or both) by a wartime economy, with subsidized research and development, that have caught the fancy of many of our youth of ability. Lest there be misunderstanding, it must be said that most of the glamour jobs also offer real opportunities for an expanding career, but the division of talent, in recent years, has been unfortunate.

Attraction of youth toward these spectacular operations is natural, and perhaps even the inevitable sequel to the comic book, collossal movie, home-run cereal, interplanetary travel, ray-gun diet on which our younger generation has been nurtured. When confronted daily with a galaxy of spectacles, it is naturally and understandably difficult to look ahead very far. Thus we have not had to sell, beg, and cajole youth into ultrahigh-frequency work, jet engines, or aeronautics. While these fields need more and more men, they already have more than their proportionate share of America's scarce young technical talent, and the trend continues in their direction.

What, then, is the solution for those employers whose interests remain to a large degree in the power field? What should they do, or better yet, what have they not done that has led to this disaffection from the area of power equipment? Several points are important, but the most signal by far is the fact that the power equipment manufacturer has been so well established and so well accepted as a day-to-day necessity, that the average parent, student, or counsellor forgets about our existence. When one eats a slice of bread or drinks a glass of milk, one never notices the brand name on the package, but the label on a new antihistamine or a new chlorophyll dentrifrice catches one's attention, and sometimes holds it for a while. The former products are not only more vital; they provide the basis for stable industry, for tens of thousands of jobs and thousands of outstanding careers, but the latter have momentary glamour, more publicity, and a measure of popular appeal. It should be possible, with long-range thinking, to dispel some false impressions concerning opportunity for young men in electric power work, but not unless all concerned with this problem make a realistic effort to reinterest youth in our industry by making the opportunities plainly evident.

EDUCATIONAL FLEXIBILITY

BEFORE RELATING A FEW of the advanced developments that spell real opportunity for young engineers in power work, mention should be made of one bright side to the situation under discussion. For several years those electrical manufacturers who have placed strong emphasis on orientation, training, and continued education programs have urged the engineering colleges to stress fundamentals in their undergraduate curricula, leaving specialized training to the employer and to the graduate school, for that small percentage who are both qualified and motivated to strive for advanced degrees. In recent years, many of the colleges have stressed basic fundamentals in their technical curricula, and the difference in actual educational background between power, electronics, and communications options is small indeed.

This has been most fortunate indeed for the electrical manufacturer who has often found that he can select men for employment as graduate student engineers, regardless of their choice of option in engineering college. Once inside industry, these young men of assorted educational background begin to see the unlimited horizons ahead of them in many of the older, well-established, yet still rapidly expanding departments of electricity. At this point their particular specialty in electrical education can be forgotten easily, for if the opportunities in power call to their imagination and ambition, their fundamental training has prepared them to take a responsible position

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Special article recommended for publication by the AIEE Committee on Education.

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and build a career in the development or design of power apparatus.

Since World War II, hundreds of young men who were attracted to electronics in college have embarked upon fruitful careers in power engineering in the writer's organization. They are going ahead, they are truly motivated in their jobs, and they have suffered no handicap because they did not elect the "power option" in college. One significant factor in the progress of these men is the program of continued education made available to them in a convenient and economical form, through the excellent cooperation of 11 accredited colleges. Advanced technology in power is quickly assimilated and put into practice.

MANAGEMENT OPPORTUNITIES

Another point of importance is this. Quite a large number of the new electrical engineering graduates each year aspire toward management status in their future careers. There always will be great careers in pure technology, but a larger number of those that we someday will call "successful" will have management positions in industry. They will supervise the efforts of other technologists, they will plan, they will budget, and they will direct and administer. Where can such men better realize their objective than in the power utility business or the electrical manufacturing industry? It is probable that a detailed analysis would reveal that the total number of administrative and policy level positions in the utility and electric machinery manufacturing companies of America compares favorably with such opportunities in other major industries, and the power segment of our economy is a well-established and stable industry.

As further evidence of the unparalleled opportunity present in American industry, reference should be made to an analysis made last year by one of our large educational institutions. It showed, as a result of a survey of a good cross section of industry, that over 40 per cent of all the policy-level management of American industry are graduate engineers, and this percentage will continue to grow every year. Another survey made about 4 years ago indicated that of the 150 largest producing corporations in America, 50, or one-third, had as their chief executive officer, a graduate engineer. This number will continue to grow too, for it is a necessity if we are to continue our terrific pace forward in engineering, production, and national strength. Consistently, engineering becomes a requisite for more and more of the key positions of industry.

Thus, regardless of option, specialty, or even branch of engineering, those who aspire to administration have a tremendous opportunity in industry just because they are engineers with ambition and a true desire to make their mark in American industry.

MAJOR DEVELOPMENTS

It is worth while to review briefly developments in a few of the major equipment lines that are currently achieving noteworthy advances in the power field. In this manner the great opportunities present for young men in power engineering can be pointed up, in addition to the management positions just discussed.

A major interest in our industry always has been power generation, and some of the most recent developments in turbine-generators present a most interesting picture of the challenging engineering met by men in this line of work. The author's company recently accepted an order for two units to be rated 250,000 kw each. Nowhere in the world are there machines of this rating in existence, and to make the design of these units even more spectacular, they are to be 2-pole 3,600-rpm machines. A little more than one decade ago, engineers hesitated to tackle the design of 3,600-rpm units of one-quarter this rating! Certainly this is progressive engineering of the highest degree, so how has it become a reality? These behemoths will employ insulating materials developed within the past 5 years far superior to anything previously utilized. Even more important, they will have inner-cooling of both the rotor and stator windings. Through this novel innovation, hydrogen under pressure is circulated through the generator windings, thus removing heat directly into the coolant, without first having to transmit it through the conductor insulation. Numerous additional design improvements will be used, all of which are intensely interesting, but which present too much detail for this discussion. Incidentally, the turbines which will drive these electric giants will operate at 1,050 degrees inlet temperature, and with steam at 2,000 pounds per square inch. The continued development work in the field of generation makes the electrical manufacturer confident that the ultimate in size, efficiency, and reliability is far from reached.

At various times mention is made of less conventional sources of power, some of which may sound novel indeed. Among these are solar collectors, wind power, heat pumps, tidal energy, atmospheric electricity, and so forth. While these are all possible sources of power, most of them have been used only experimentally. As the availability of fossil fuels (coal, oil, gas) is reduced and their cost increases, some of these other forms of energy, fanciful as they may seem now, unquestionably will be developed. Here is, indeed, long-range opportunity and challenge for the power engineer. Along these same lines, to an extent, comes the field of atomic power generation. Today no one sees a way of converting directly from fissionable materials to electric power. In other words, to obtain power from an atomic reactor it is necessary to go through some form of heat exchanger, and turbines and generators similar to those now used will comprise the electrical elements of the system. However, the real possibility should not be ruled out that some scientist will come up with a single idea, a basic one that will permit direct conversion from fissionable material to electric energy, and then the new fields open to the power development engineer have horizons beyond present imagination. Some of our most practical research leaders do not vision this "idea" as fanciful, but rather just a matter of time and the appearance of the right young scientist with a fresh approach and a spark of genius.

With the general growth of the power systems in America, and the installation of larger generating units, the necessity for larger and larger transformers becomes apparent.

The actual limitation on maximum transformer size today is determined by shipping requirements. Fifteen years ago the largest transformer built in this country was about 60,000 kva single phase. Today the writer's company is building 220,000-kva 3-phase units, and these will be shipped assembled, not in two pieces as were the 60,000-kva units so few years ago. Such advance is only produced through the collective effort of power electrical engineers exercising their ingenuity and creative genius at every turn. The present trend will continue, and the future will hold larger transformer ratings to satisfy the needs of our expanding power industry, only made possible by the work of power electrical engineers motivated toward real professional achievement.

It is worth while to take a brief look at high-voltage transmission. The highest commercial operating voltage in the United States today is 287 kv, this being the level of the Hoover Dam lines, which have been in operation for more than 15 years. A transmission system utilizing over 300 kv is now in the making in America, and studies point to even higher voltages when they are proved to be needed. The equipment has been substantially developed, and future power engineers will have the opportunity of extending this trend just as far as the power utilities demand. Power level and distance will determine the need, but forward-looking engineers today frequently recommend a voltage level higher than immediately indicated—because with today's accelerated growth curves, it is a safe bet that money will be saved in the long run.

Developments in circuit interruption have been quite rapid. It is only a very few years ago that the maximum proved interrupting rating of power circuit breakers was 2,500,000 kva. Today 10,000,000-kva capacity circuit breakers are a regular production item and units of much higher rating are currently on order. The engineers responsible for design are fully confident of meeting the job requirements. More ingenious than interrupting rating itself, is the ultrahigh-speed reclosing power circuit breaker. The job of opening such a giant mechanism, extinguishing the arc, and reclosing it in not more than one-fourth of one second is a heralded achievement of both electrical and mechanical engineers. If it becomes necessary to operate a circuit breaker faster to meet system stability, or other requirements, it is almost a certainty that engineers in this field of technology would meet the need promptly. They would likely be young engineers, and they would take great pride in their accomplishment, as will many other young men who place their future in the power field.

A major part of the investment of our power utilities is in the distribution system. It is greatly important to these producers of power that engineering emphasis be placed upon developments in distribution apparatus. The number of innovations in this field are great, and they will continue to be. Most of these accomplishments are not spectacular, but they result in a major portion of the savings that keep electric energy cheap in America, and they provide extensive opportunity for youths who have both imagination and a practical sense of engineering economics. Successful careers in the distribution area will be divided between equipment development and the development of new methods and systems of distribution.

SUMMARY

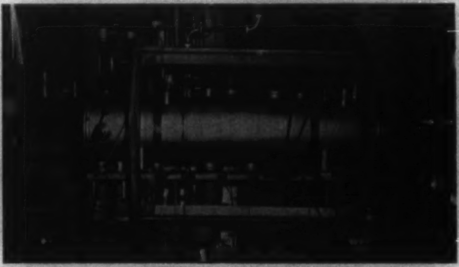
It is certainly easy to go on indefinitely pointing up the possibilities for stimulating professional work for the young man who chooses power electrical work. In a brief discussion, it is only possible to mention a few of the current areas of development effort, and thus only a few typical opportunities for young men to exploit their creative genius.

Traditionally, the power industry in this country has doubled in capacity every decade. The present period substantially exceeds this rate. The electric equipment manufacturers have a real need for young men trained in college for this field of technology. Most of the equipment manufacturers will agree with the opinion that this power education should be as basic, or fundamental, if that name is preferable, as can be designed to fit the usual 4- or 5-year undergraduate period. The employer must assume the responsibility for specialized education, after the young graduate has become acclimated to his industrial environment, and is thus in a position better to choose his field of special interest.

In the ranks of management, the need for young power engineers with high ultimate potential and broad scope of interest is demonstrated both statistically and by comprehensive survey of individual company managements. In the field of pure technology, the need for men motivated toward creative engineering achievement scarcely can be challenged in view of the accelerated rate of present accomplishment and the unlimited horizons ahead.

In the power field, as in any other field of progressive engineering, our society demands the best that our youth of ability and ambition can deliver.

Cesium-Beam Atomic Clock



A highly precise frequency and time standard developed by the National Bureau of Standards, the clock depends on the resonant properties of the cesium atom at about 9,200 megacycles, where a hyperfine-structure spectrum line is excited. The device uses a beam of cesium atoms about 125 centimeters long, moving at thermal velocities. The cesium spectrum line has been excited to a Q of 30 million, the sharpest resonance ever observed. A precision of 1 part in 10 billion can be achieved

Field Studies of Generator Windings

H. C. MARCROFT
MEMBER AIEE

Expendable armature windings of a-c rotating machinery are subject to various kinds of damage which are becoming better understood. Tests of windings, available through failure or aging, yield important design data.

Three insulations are of importance in multiturn armature coils, namely, insulation around individual strands of copper; insulation around each turn of the coil which usually contains a number of strands; and insulation over all the turns together constituting the barrier between conductors and core. Generator windings may fail due to weakness or failure of the over-all ground or turn insulation caused by improper materials or fabrication, vibration, temperature cycles, machine short circuits, corona, or other causes. Nondestructive d-c tests, such as insulation resistance and dielectric absorption, can be used to indicate general moisture condition. A-c tests of power factor, especially on individual coils, are useful for indicating corona effects. Turn separation defects are detected by applying high-frequency potentials of sufficient magnitude.

Dielectric absorption tests using d-c test equipment capable of reaching 45 kv may be used judiciously at lower voltages for nondestructive tests; similar tests at increased voltage levels may be used where a possible breakdown can be tolerated. High-voltage d-c 10-minute absorption tests on a 6,000-kva 11-kv 25-cycle generator with Class *B* ground insulation, shown in Figure 1, indicate:

1. Breakdown tests at d-c potentials correlate with peak value of a-c potentials.
2. D-c breakdown may occur suddenly, without significant change in charging current or resistance. Proof potentials, therefore, should be limited as required.
3. In d-c tests where charging current shows variation, breakdown is indicated at about the same a-c rms voltage.

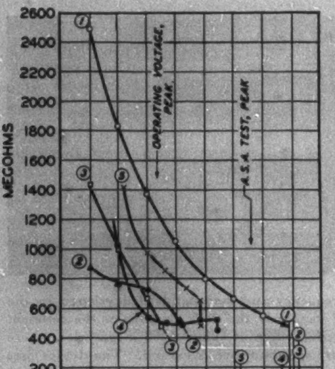


Figure 1. D-c high-voltage tests on 6,000-kva generator showing resistance change with voltage, using 10-minute time values. Arrows indicate peak value of breakdown

Failures: 1—By d-c test 2—By a-c run-up test 3—By a-c run-up test 4—By a-c 1-minute step test 5—By a-c 1-minute step test

The problem of failures of coils between turns by short circuit was investigated on five generator windings of different types available for destructive tests. This was done by isolating individual coils, while in the generators, and making each coil in turn a part of a resonant circuit consisting of a 15-kv capacitor, a spark gap, and the generator coil. Potential across the coil was measured with a sphere gap and the magnitude was regulated by the spacing of the adjustable series gap. A current instrument and search coil in inductive proximity indicated failure of the generator coil.

The results of the survey on the five generators showed that in the cases where the windings had failed by turn-to-turn short circuit during operation, there were other coils in the winding at subnormal turn insulation levels. In the case of two large water-wheel-driven generators there were no operational failures and the turn insulation tests showed high levels of insulation strength in spite of the great age of the windings. These coils had mica-tape turn insulation with the addition of a strip of mica between turns.

In the case of a 6,000-kva frequency changer, a much newer machine, having coils with no turn insulation other than the double cotton strand insulation, six coils had voltage breakdown levels considerably under 1,000 volts rms, and one as low as 250 volts rms. The corresponding separations between copper were: 0.35, 2.8, 3.7, 5.0, 6.0 6.0 mils of air. Average separation in the machine was 20 mils (assuming air dielectric). This machine was favored by absence of vibration, long idle time, and short core. Due to the close grouping of the weak coils, it may be supposed that these coils were the ones in the original jump.

Steam-turbine-generator coils were found to have 80 mils nominal spacing between copper consisting of mica tape wound around the turns. A few coils failed on test at 5,000 volts per turn and one failed at 3,330 volts per turn.

Turn-to-turn tests, to be of value, must be of sufficient potential to break down an air gap which is considered to be minimum for the coil in question. Minimum voltage breakdown of air occurs ordinarily at 0.316 mil between flat plates and requires 240 volts rms; greater or lesser separations require a greater potential than 240 volts according to a function of Paschen's Law. Turns almost touching each other may require potentials to break them down greatly in excess of operating voltage between turns, so if insufficient test voltage is used, coils will indicate clear of short circuit on test, yet fail when the temperature is increased, as when long-core steam-turbine-generator coils sometimes fail shortly after taking full load after being idle.

Digest of paper 52-209, "Field Studies of Generator Windings," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in the AIEE *Transactions*, volume 71, 1952.

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Cathode-Drift Compensation in D-C Amplifiers

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THE PHENOMENON of cathode drift represents one of the more troublesome sources of drift in direct-coupled amplifiers, and although the exact mechanisms involved have not been completely explained, it is generally accepted that the conditions of drift can be simulated, for analytical purposes, by the assumption of a random noise-voltage generator in series with the cathode of the tube in question.

Such an assumption provides the basis in this article for the analysis of the Miller Circuit which seems to have an excellent ability to compensate for the effects of cathode drift, but which has had associated with it the limiting condition that the amplifier load resistance, R_L in Figure 1, must be large enough to make the amplifier plate current, i_1, small compared to i_2. The purpose of this article is to demonstrate that such a limitation does not exist and to propose a variation of the Miller Circuit which has some advantages in many applications.

The a-c equivalent circuit for the Miller Circuit with the grid of T_1 grounded, is shown in Figure 2 where r_1, μ_1, r_2, and μ_2 are respectively the plate resistances and amplification factors of T_1 and T_2.

An analysis of Figure 1 reveals that with the grid of T_1 grounded:

$$e_{g1}=(i_1+i_2)(R_1+R_2)-e_n \tag{1}$$

and

$$e_{g2}=(i_1+i_2)R_1-e_n \tag{2}$$

Using equation 1 to sum the voltage around the top loop of Figure 2, the following expression is obtained:

$$i_1[(\mu_1+1)(R_1+R_2)+R_L+r_1]+i_2(\mu_1+1)(R_1+R_2)=(\mu_1+1)e_n \tag{3}$$

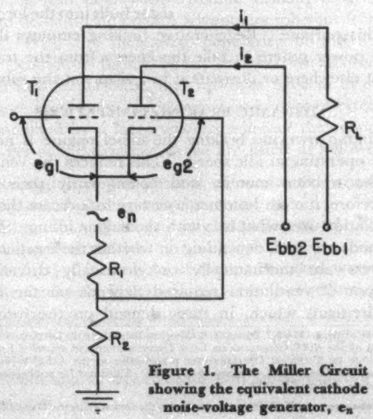

Figure 1. The Miller Circuit showing the equivalent cathode noise-voltage generator, e_n

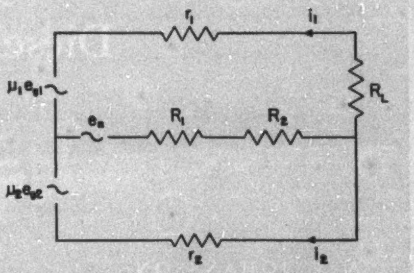

Figure 2. A-c equivalent circuit for Miller Circuit showing the equivalent cathode noise-voltage generator e_n

A similar summation around the bottom loop of Figure 2, yields the following expression:

$$i_1[(\mu_2+1)R_1+R_2]+i_2[(\mu_2+1)R_1+R_2+r_2]=(\mu_2+1)e_n \tag{4}$$

Simultaneous solution of equations 3 and 4 for i_1 and equating $\partial i_1/\partial e_n$ to zero yields as a criterion for cathode-drift compensation:

$$R_2=\frac{1}{g_{m2}} \tag{5}$$

where g_{m2} is the transconductance of T_2.

This result is identical to the one obtained by Miller, but no assumption whatsoever, regarding the relative magnitudes of resistances or currents, is made here; so it would appear that this circuit should provide compensation whether R_L, Figure 1, is large or small.

If the resistor, R_1, in Figure 1 is short-circuited and a load resistor is introduced into the plate lead of T_2, the noise voltages that otherwise would develop in R_1, and undergo amplification by the tube, can be eliminated with little sacrifice in cathode-drift compensation provided that in the new circuit the remaining cathode resistor, R_2, is made equal to $(1/g_{m2}+R_{L2}/\mu_2)$ where R_{L2}, g_{m2} and μ_2 are respectively: plate load resistor, transconductance, and amplification factor for T_2.

Since the foregoing findings have been experimentally confirmed, it is believed that this discussion will serve to broaden the potential field of application of the original Miller Circuit by removing an unnecessary limitation. It is further believed that appreciable benefit may be derived from the additional possibilities that are available through the proposed modification of Miller's circuit.

Digest of paper 52-244, "Cathode-Drift Compensation in D-C Amplifiers," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Phoenix, Ariz., August 19–22, 1952. Not scheduled for publication in AIEE *Transactions*.

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Dynamic Braking on Diesel-Electric Locomotives

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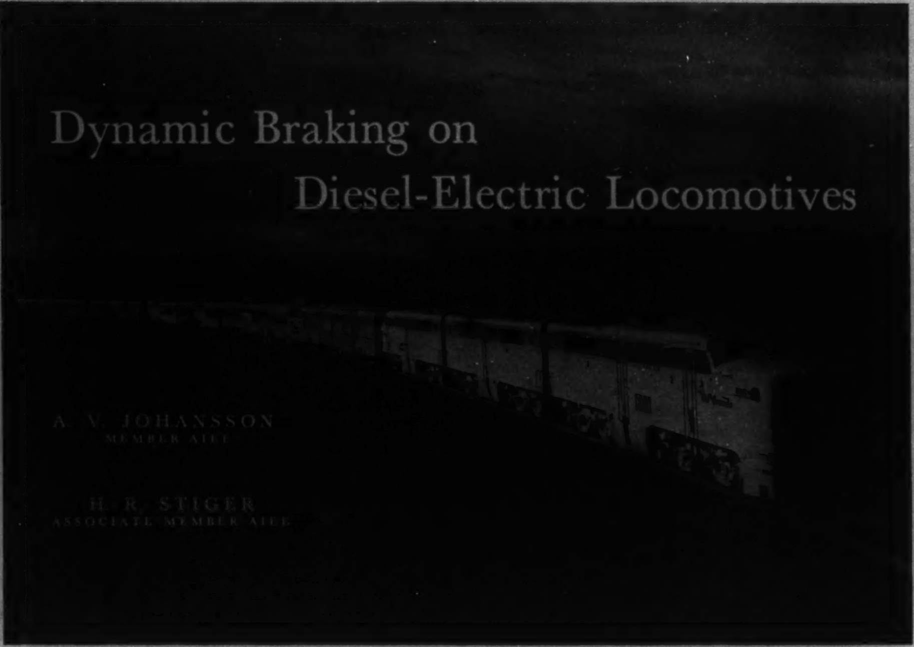

The increasing prominence of the diesel-electric locomotive on American railroads has given new impetus to the use of dynamic braking. A recent refinement of braking control takes advantage of additional traction-motor capacity available at low speeds and service tests have shown the operational and economic value of this form of braking.

ONE OF THE great advantages of the diesel-electric locomotive over steam motive power is its ability to provide dynamic braking. When operating in dynamic braking, the traction generator is used to excite the fields of the traction motors, Figure 1. The motors then act as separately excited generators, driven by the motion of the train, and produce a voltage. When resistors are connected across the motor armatures, this voltage causes current to flow and load the motors. As a result they produce a torque which opposes the torque produced by the wheels.

The advantages of dynamic braking are greatest in mountainous territory, but it has been found valuable also on railroads not having heavy grades. In such cases the dynamic brake provides a quick, easy means of applying retarding force to the train when its speed must be restricted, and for bringing it almost to a halt when a stop must be made. The latter is of particular advantage for freight trains. As a rule the reduction of braking effort as the speed decreases makes the braking rate too low for passenger trains.

There is nothing particularly new about the basic idea of dynamic braking. It is a simpler form of the regenerative braking used on electrified roads years before the diesel-electric locomotive came into being. The prime difference between dynamic and regenerative braking lies in the method used to dissipate the power produced. Dynamic braking uses a resistor built into the locomotive for this purpose. Regenerative braking employs the railroad power system to take the energy from the train and use it elsewhere or dissipate it in resistors at the substation.

DYNAMIC BRAKING LIMITATIONS

DURING DYNAMIC braking the diesel engine is normally operating at idle speed. This reduces the ventilation to the traction motors, and consequently their rating. Therefore, it often becomes necessary to increase the motor ventilation over what it is with the engine idling. Various methods are used, depending on whether the traction motor blowers are mechanically or electrically driven. The amount of ventilation required depends on the braking requirements which, in turn, depend on the locomotive

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Full text of paper 53-48, "Dynamic Braking on Diesel-Electric Locomotives," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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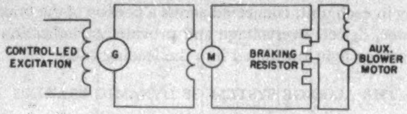

Figure 1. Fundamental circuits for dynamic braking

application. On special locomotives this requirement is cared for in the design. On standard locomotives the braking provided is, naturally, that which can be most economically obtained, consistent with high quality. Operating experience indicates that it meets average requirements.

Normally the requirements on the traction generator are not limiting during dynamic braking. Rather, the traction motors are the limiting part of the system in the following ways:

1. Field current (I_f), which is limited by heating.
2. Armature current (I_a), which is limited by heating.
3. Peak volts per bar (V/B), which is limited by motor design.

The way in which these affect a braking effort curve is shown in Figure 2. In the past, armature current during braking had to be limited to a maximum value that would not exceed the safe heating limit of the motors at high speed where the core loss is greatest. This meant that the braking effort followed the Constant I_a curve in Figure 2, and the maximum possible braking effort available at lower speeds could not be utilized. The latest Alco-GE system provides automatic control of the traction-motor current to hold it within safe heating limits at all speeds. The result, as shown in Figure 2, is that greater braking effort is available at lower speeds. At higher speeds the peak-volts-per-bar limit still exists. This requires a manual reduction in motor armature current as indicated at the right-hand end of the curves in Figure 2.

OPERATING ADVANTAGES OF DYNAMIC BRAKING

Years of operating experience, first with regenerative braking and later with dynamic braking also, have served to demonstrate certain advantages inherent in these systems. With the increasing popularity of the diesel-electric locomotive during the last decade these advantages assumed new importance, and railroads tried to evaluate them more accurately. In a report on a series of extensive tests conducted by a large western railroad[1] the economic advantages of the dynamic brake are listed as follows:

1. Reduction in the number of overheated wheels in both freight and passenger equipment.
2. Elimination of long, costly stops for wheel cooling in heavy-grade territories.
3. Reduction in number of thermal cracked wheels.
4. Reduction in wheel wear as a result of reducing the use of air brakes to a minimum.
5. Reduction in wearing of parts of brake rigging and attachments.
6. Reduction in brake-beam and brake-beam-attachment failures.

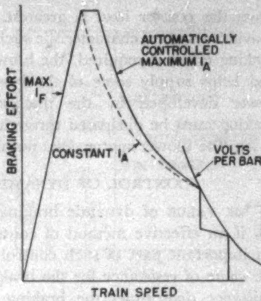

Figure 2. Braking effort curves, showing the effect of automatic control of armature current

7. Reduction in number of derailments caused by failures of brake beams and brake-beam attachments.
8. The ability to reduce train speed with the dynamic brake in conjunction with the air brake without attendant brake-shoe and wheel damage.
9. Better train handling in regard to slack action where dynamic brake is properly used.

BRAKING RESISTORS

A suitable resistor, Figure 3, must be provided to control the amount of energy produced by the traction motors and, therefore, the braking effort of the locomotive. The design and construction of a locomotive-mounted resistor for dissipating such large amounts of power is not simple. Yet it appears safe to say that the problem is simpler with a fixed resistor load than it is with regenerative braking where the power system is the load. In that case the voltage level of the power system is constantly changing, often very sharply, over a wide range.

The design and construction of the braking resistor is a study of its own, and we can touch upon it only briefly here. Practically all dynamic braking resistors are forced ventilated. This is necessary because space is at a premium. In nearly every case, the blower is driven by a series motor that receives its power from connections across a portion of the braking resistor itself. This provides a dependable source of power and eliminates the need for control devices. It has the advantage that the blower motor runs at a speed roughly proportional to the load on the grids which it must cool. Therefore, maximum cooling is provided

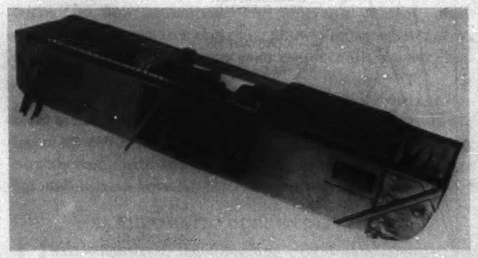

Figure 3. Forced ventilated dynamic braking resistor assembly

when the resistor load is greatest. This connection also provides a system characteristic such that when the greatest braking effort is required, the blower load is a maximum and helps supply some of the braking effort. Since the power developed by the traction motors in dynamic braking must be dissipated through the resistor, the power to run the blower motor costs nothing.

CONTROL OF DYNAMIC BRAKING

The value of dynamic braking would be largely lost if an effective method of controlling it did not exist. An important part of such control lies in the selection of the value of resistance for the braking resistor. How this resistance determines the braking curve is illustrated in Figure 4. This shows two curves of braking effort, *ABC* and *ADE*. Curve *ABC* has a braking resistor twice that of *ADE* in ohms. Lines *AB* and *AD* represent maximum field current which may be applied to the traction motor without excessive heating. This is the same for both curves. Figure 4 shows that, other things remaining the same, half the resistance allows maximum braking effort to be obtained at half the train speed. The armature current is the same for both curves, so the braking horsepower depends on the resistance and will be in proportion to the resistance value selected. These curves also show that maximum braking effort is independent of resistance; but, braking effort for any particular speed—above that for maximum braking—is directly proportional to resistance and, of course, to horsepower. Since the horsepower is a function of the resistance selected—assuming traction-motor field and armature-current ratings to be fixed—the train speed for maximum braking effort will rise in proportion to the horsepower.

Most diesel-electric locomotives are equipped for multiple-unit operation. In such use the engineman must be able to control all units by operating a braking handle in the lead unit. With this handle he ultimately controls field current, from a separately excited source, for the traction motors. By watching the traction-motor ammeter, he controls the run-in of slack on the train when he first applies dynamic braking, and later avoids exceeding the operating limits imposed upon him. A brake warning relay in each unit, connected across a portion of the braking resistor, detects overvoltage and provides an indication on a warning light trainlined into the leading cab.

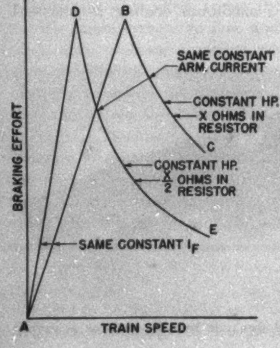

Figure 4. Typical braking effort curves, showing effect of varying resistance value of braking resistor

THE ALCO-GE SYSTEM OF DYNAMIC BRAKING

The dynamic-braking control equipment on a modern Alco-GE locomotive includes the braking resistors and a pneumatically operated, 2-position braking switch which sets up motoring or braking connections. In addition, two braking relays set up control and excitation circuits for dynamic braking, and a third relay provides the brake warning as described. In the engineman's control stand there is a commutator rheostat geared to the braking handle. The brush arm is connected potentiometer style to provide a source of voltage which may be sent back over a train wire to the other coupled units. This voltage determines the amount of traction-motor field current provided, up to the limit of traction-motor armature current. When this point is reached the armature current provides a signal which overrides the manual control and automatically regulates the field current to maintain a predetermined armature current. On some types of Alco-GE locomotives the armature current is modulated by train speed. Additional dynamic-braking equipment consists of certain reactor windings used only in dynamic braking, a small rectifier, and certain small resistor tubes.

Figure 5 shows a schematic diagram of the system with most contacts and adjustments omitted for simplicity.

At the left of the sketch are four traction motors (numbered *4*, *2*, *3*, and *1*) and their braking resistors. Across a portion of the resistor for motor *3* is the blower motor *K* and the brake warning relay *BWR*. Across another portion of the same resistor is the current-measuring coil on the reactor *X3*. This coil and its associated resistor are used to measure braking current in terms of voltage across a portion of the resistor.

The traction generator *G* is shown connected to supply current to the four traction-motor fields in series. The common connection of the generator and the four traction-motor armatures simplifies the switching required to go from motoring to braking. It also provides ground relay protection during braking through the relay coil *GR*. The generator starting winding, a series winding used in cranking the engine, is connected in the generator circuit during braking. It provides a differential effect which requires the exciter to work at a higher level of excitation. The voltage drop across the generator commutating field is used to measure motor field excitation by means of coil *D1-D2* on reactor *X1*.

An amplidyne exciter *E* feeds the generator shunt field *GS-GSS*. The generator field current flows through coil *D3-D4* on reactor *X3*, which measures generator field current. To permit a simple adjustment of the effect of the current in this reactor coil, proportional current from the exciter is fed into the *D2-D1* coil on the *X3* reactor.

The exciter shunt field *F1-F2* is fed from the transformer *T1* through the rectifier *R1*. The exciter field current is controlled by having the rectifier feed into resistance *152* whose voltage may range from a few volts below that supplied by the rectifier to a few volts above it. The

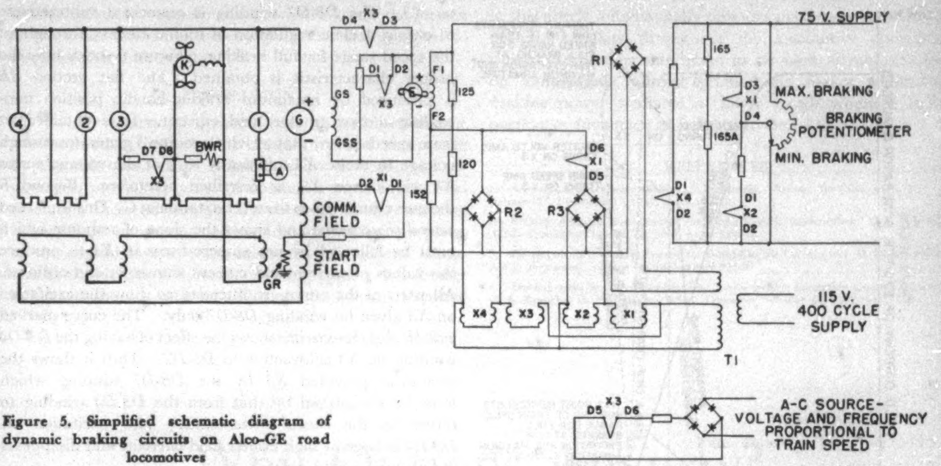

Figure 5. Simplified schematic diagram of dynamic braking circuits on Alco-GE road locomotives

difference is available to control current flow through the exciter field in one direction or the other. At the right is the braking potentiometer with its brush arm in the minimum braking position, that is, as it is immediately after setting up the braking circuits. This allows maximum current to flow through the *165* resistor and the *D3-D4* coil on *X1* to the other side of the 75-volt d-c supply. This gives maximum battery bias on *X1* and no bias on *X2*, which is short-circuited. Reactor pairs *X1-X2* and *X3-X4*, arranged as voltage pairs, are connected across another secondary of transformer *T1*. With constant voltage applied to each pair, saturation of either reactor in the pair by means of direct current will increase the voltage across its mate. Saturation of *X1* will increase the voltage across *X2*. This voltage, rectified by *R3*, appears as a higher voltage on resistance *152*, reducing the current in the exciter field. In minimum braking, the d-c bias on *X1* fed by resistor *165* is sufficient to decrease the field current very nearly to zero. We want substantially zero braking when going into braking. This requires zero motor field excitation. With this condition no current would flow in the *X1* coil *D1-D2*, connected across the generator commutating field. If current did flow, it would further saturate reactor *X1*, and further reduce the exciter field strength. This would decrease the generator excitation and reduce the motor field current.

To sharpen up the control, particularly desirable in minimum braking, the boot-strap winding *D5-D6* on *X1* is used. This winding, shown immediately above rectifier *R3*, takes the output of reactor pair *X1-X2* and uses it further to excite *X1*. Up to this point the effect of the three windings on the saturation of *X1* has been additive. The terminal symbols *D1-D2*, and so forth, are established for each winding so that current flowing from *D1* to *D2* will be additive with current flowing from *D*-odd to *D*-even, in any other coil on the same reactor and, of course, subtractive for reverse polarity.

After the slack has been run in, more braking is desired. The engineman moves the braking handle so that the potentiometer brush-arm turns toward the maximum braking position, and provides a voltage of increasing value. This increases excitation on *X2* reactor, which has only one d-c coil. Thus more excitation is required on *X1* to return to the same value of voltage across *X2*. At the same time, the range is extended still further by decreasing the additive current in the *D3-D4* winding, and finally reversing it as the brush-arm reaches a potential above that of the mid-point of the *165-165A* voltage divider.

The incremental transient decrease of the voltage across the *152* resistance allows more exciter field current to flow. This, in turn, causes more motor field current to flow, producing more drop across the generator commutating field. As a result more current flows through the *D1-D2* winding of *X1*. This winding thus controls the exciter field current at points above minimum braking, with the values controlled being preset by the braking potentiometer brush-arm voltage. The current in this winding is determined by generator excitation and is controlling the exciter field current. Hence for a given braking handle position, a balance point is reached where the current in the commutating field allows just enough exciter field current to flow to maintain the generator current. Any decrease in generator current allows more exciter field current to flow, and any increase reduces the exciter field strength.

In this way the *X1-X2* reactor pair provides the engineman with control of braking current as long as he does not try to exceed a preset limit. He controls the leading unit directly and, with the same potentiometer, the other units through a train wire.

AUTOMATIC CURRENT LIMIT

UNTIL RECENTLY, the foregoing description covered the entire system of dynamic braking control on Alco-

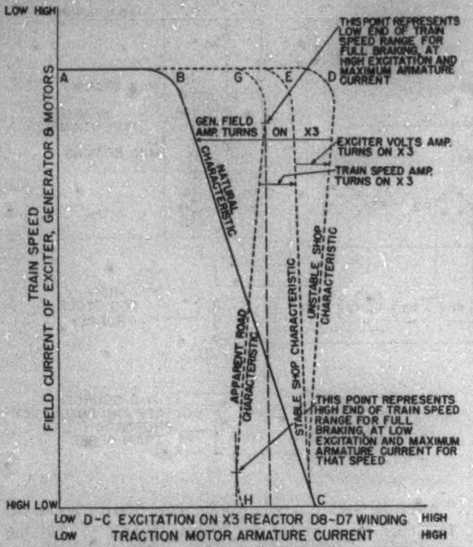

Figure 6. Controlled braking characteristics. Note that the entire characteristic may be shifted to the right or left by changing X4 D1-D2 ampere turns

GE locomotives. Now, however, a current limit based on traction-motor armature current has been introduced. This provides an overriding control of braking, preset and automatically regulated. With it the engineman can control dynamic braking with much greater ease, since he need not watch his ammeter or brake-warning light so closely. It protects the equipment by preventing accidental or deliberate overloads. It provides a better balance of braking between coupled units, because it goes deeper into the system to take a measurement of output. Instead of motor field current, it measures motor line current. This substantially eliminates the effects of varying motor characteristics and wheel sizes between units. Of course, it does not eliminate these factors between motors of the same unit. As applied to Alco-GE road locomotives, this refinement allows greater braking at low train speeds than at high speeds. It does this by taking advantage of the lower core loss at low speeds, allowing more copper loss for the same motor heating. To do this with ordinary engineman control of dynamic braking would be very difficult. It would require complex operating instructions which probably would prove most confusing to the engineman.

In Figure 5 is a winding *D8-D7* of reactor *X3* connected across part of the braking resistor for motor *3*. This winding measures the braking current in motor *3*, and controls the voltage across resistor *152* whenever the voltage across *X4* exceeds that across *X2*. The generator field current in braking also flows through the *D3-D4* coil on *X3*. The *D8-D7* winding is connected subtractively to obtain a close regulation of motor current throughout the speed range for full braking. Figure 6 shows how the proper characteristic is obtained. The flat section *AB* is produced by maximum braking-handle position controlling a fixed motor field current. It is obtained at train speeds below that at which motor *3* generates enough voltage to excite *X3* sufficiently so that the voltage across *X4* will exceed *X2*, as described heretofore. Beyond *B* the curve turns down to zero excitation at *C*. This is marked *natural characteristic* and shows the slope of response which must be followed by net ampere turns in *X3* to produce the values of exciter field current shown by the ordinate. All parts of the curve are intended to show the excitation on *X3* given by winding *D8-D7* only. The curve marked *unstable shop characteristic* shows the effect of having the *D3-D4* winding on *X3* subtractive to *D8-D7*. Thus it shows the excitation provided *X3* by the *D8-D7* winding which must be diminished by that from the *D3-D4* winding to return to the *natural characteristic*. The excitation on *D3-D4* is large at high exciter field currents and disappears at low exciter field currents.

The curve just discussed is unstable on the road because less output of motor *3* would result in more excitation on the exciter and conversely. So an additional winding on *X3*, properly adjusted and connected across the exciter armature, is used to decrease the effect of the *D3-D4* winding without working with heavy-current low-voltage windings of a fixed number of turns. This restores the characteristic to that marked *stable shop characteristic*. It is the curve sought in standstill adjustment of the system where battery voltage, through a suitable rheostat and instrument, is used to simulate motor *3* voltage.

All recent Alco-GE road-type locomotives with dynamic braking have been equipped with a recalibrating winding on *X3*. Since this is fed from the locomotive axle generator through a rectifier, it receives a d-c signal proportional to train speed. This provides excitation additive to that provided by the *D8-D7* winding. The result is to recalibrate the system so that less motor current will flow at high speeds than at low speeds. Thus advantage is taken of the reduced core loss at low speeds. This produces the curve marked *apparent road characteristic*. Although it has a negative slope it is not unstable because an outside element—train speed—controls the slope. Actually this curve is simply the *stable shop characteristic* cut back varying amounts at various train speeds. Any transient changes follow the slope of the *stable shop characteristic*.

This method of automatically controlling maximum braking current provides regulation without using any moving parts except the setup devices. The *unstable shop characteristic*, Figure 6, is actually stable in the shop if a separate source of power is used for the *D8-D7* winding on *X3*, but would be unstable on the road. If an incorrect adjustment or other defect produces this sort of characteristic on the road, the effect of the connection of the *D8-D7* winding across a portion of braking resistor which is in series with the blower motor results in minimum hunting. The motor tends to hold the voltage constant across its section of resistance. This makes any transient change in voltage appear almost wholly across the section of resistance adjacent, thereby giving a leading signal to the *D8-D7* coil on reactor *X3*.

CONCLUSION

THE POPULARITY of dynamic braking on diesel-electric locomotives indicates its desirability and acceptance by the railroads. This is based upon its economic advantages, proved by years of operating experience. Furthermore, these advantages are obtained by the addition of very little equipment not required for traction purposes, so the capital investment is relatively insignificant. Progress in the design of dynamic braking systems has further enhanced the advantages. The refined system described in this article automatically provides maximum permissible braking capacity throughout the locomotive operating range. It permits this brake to be used advantageously on almost any railroad profile, and makes additional braking power available at lower speeds where it is of particular advantage in freight service.

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Why Options Anyway?

K. B. McEACHRON, JR.
FELLOW AIEE

With industry becoming increasingly interested in the engineering graduate with strong training in basic sciences, it is time to review the causes and reasons for specialized engineering education. Options in their present form are creating some serious problems and changes in curricula should be made both to interest students in engineering and to answer industry's insistence upon more fundamentals in science and mathematics.

ANY DISCUSSION OF options in curricula necessarily must concern itself with the function of such options in helping to achieve the broad objectives of engineering education as a whole.

Not too many years ago, most industrial concerns looked to the colleges to supply them with trained technicians rather than with men on the way to becoming professional engineers. A few companies still recruit engineering graduates primarily on the basis of what they can contribute immediately rather than as long-range investments in engineering progress. As a result of such an emphasis in the past and the great expansion of science and engineering, the colleges have been faced with demands for an extreme degree of specialization in engineering education. How much this has served to fragment education and the profession generally is indicated by the fact that over 180 different degrees in mechanical engineering are given each year in the United States. Fortunately for engineering, the colleges have attempted to resist the extremes of specialization by requiring a "common core" of subjects for all engineers, regardless of the particular option or curriculum involved.

However, industry is becoming increasingly concerned about the engineering graduate who is a specialist, or thinks he is—who knows or wants to know "more and more about less and less until he knows everything about nothing." In a recent panel discussion on engineering education, Robert C. Sprague of the Sprague Electric Company stated that, on the basis of his experience with engineering graduates, one of the three fundamental requirements in the education of engineers is "intensive training in the basic and applied sciences, even at the expense of applied engineering subjects."

Mr. Sprague continues: "From my own observation, I find dramatic evidence that the man with the strongest basic training has the greatest adaptability, because the basic sciences can be applied to different problems in many branches or to a single problem which may extend into overlapping branches. In the rapidly changing technological industries such a man enjoys a tremendous advantage."

To many engineering educators, such statements by industry come as something of a shock and seem to suggest that industry really would prefer to employ science graduates for engineering work rather than engineering graduates.

Actually, however, industry is more concerned with the teaching methods employed than it is with the subjects taught. Too frequently, great attention is given to the

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details of the application itself, rather than to the way in which fundamental principles are used to solve the problem. The reaction of an engineering senior—that he studied fundamental principles of physics and chemistry in his sophomore year and now is "above" using such "childish" principles—is amusing to engineers. Such an attitude must stem from the relative emphasis which is given to these in engineering teaching. The only reason for industry to urge that more time than at present be spent in studying fundamentals of science is that the average graduate does not understand how to apply such fundamentals to new situations.

OPTIONS AS MOTIVATION FOR STUDY

Why, then, should options be continued in engineering curricula, if the emphasis by industry on specialization is decreasing and, in many cases, has disappeared? The principal argument for their continuance seems to be that options are necessary to interest the student in the particular branch of engineering concerned. If students do come to college seeking engineering specialties, such as communications, electronics, or power, then the value of such motivation can be eliminated almost completely by insulating students for nearly 3 years from any real contact with such specialties. During this period, students are being given the mathematics and science which are considered necessary as a prerequisite to work in a particular engineering field. May it not be possible that the prevalent attitude of college students, to drop from their consciousness each course as they complete it, is the result of their mental preoccupation with the courses to follow, which are "electronics," or "communications," or "power" courses? Is it not also possible that the high mortality among engineering students in their first 2 or 3 years, results from the ignoring of their initial motivation and that this causes a deep sense of frustration? And finally, do not some students, who are not really interested in engineering, find themselves just realizing this fact in their third or fourth years, when they first encounter any real engineering material? It would appear, therefore, that the existence of options in their present form is of doubtful value in maintaining a high level of student interest in engineering.

On the other hand, does the division of engineering curricula into options create any serious problems? In the January issue of *Electrical Engineering*,[1] Professor J. D. Ryder of the University of Illinois points out the shift which is taking place away from the power option and toward the electronics option in electrical engineering. Such a shift would be of much less concern were it not for the student attitudes which options seem to create; the electronics major has only disdain for the power field, and the power major has little interest in electronics. As emphasis shifts away from one option, such as power, it is almost impossible to prevent a corresponding deterioration in the quality of students who select it, and the faculty who teach. These points are well brought out by Professor Ryder. Perhaps the present power curriculum is not as inherently effective in developing the technical proficiency of undergraduates as is the electronics curriculum. If this is true, then maybe it is quite proper that future work in electrical engineering be based largely on the present electronics curriculum, but with enough broadening to provide graduates who can become successful in the power field if and when their particular situation demands. Then the two options eventually would disappear in a single curriculum.

EARLY STUDY OF ENGINEERING PROBLEMS

But the importance of motivation should not be set aside by merely saying that options in their present form do not contribute too effectively to it. As suggested earlier, students enter engineering college to study engineering and not mathematics or heat transfer. It therefore should not be out of order to suggest that they be given engineering problems, and not as juniors or seniors but as freshmen. And since many students are presumably very narrow in their interests, options in electronics, power, and so forth, should be available to them as freshmen. Problems should be complex enough to demonstrate forcibly to them their need for mathematics, science, English, and the other regular subjects in the present engineering curriculum. As students progress through such a curriculum, reasoning from specific to general and then back to specific problems, the importance of fundamental principles becomes self-evident through their power in the solution of problems. Is it an accident that fundamental principles are most often evolved as the result of experiments or specific problems? Is it not probable that the most efficient way to learn is the way the human race has learned—first from specific problem or experiment to general principle and then to new problems? Is not too much effort spent in trying to reverse the process rather than to improve it?

Such an engineering curriculum would provide the student motivation which is presently claimed for the use of options, to a much greater extent than ever before. It should be an effective answer to industry's insistence upon more fundamentals of science and mathematics in engineering education. And finally, it should help to interest students in engineering and keep them in engineering during college.

To the question "Should options be continued?," therefore, the answer is "Yes, but with a difference!"

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Magnetic Attenuator

An inexpensive type of microwave attenuator for coaxial transmission lines, developed by the National Bureau of Standards, utilizes an external magnetic field to obtain instantaneous changes in attenuation. The adjustable external field controls the losses of the ferrite that dissipates the radio-frequency energy. No moving parts, mechanical controls, or slotted sections in the coaxial transmission line are needed.

A New Heavy-Duty 3-Phase Oil Circuit Recloser

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THE ECONOMIC DESIGN of automatic circuit reclosers has been made possible through the use of a series solenoid which opens the recloser when current exceeds a minimum trip value and stores energy for automatic reclosing. As the power output of the series solenoid at minimum trip current is small, this design has limited 3-phase reclosers to single-pole operation. Single-pole operation has the disadvantage that feedback through transformer banks can prevent the interruption of transient phase to ground faults and cause unnecessary lockout of the recloser.

To obtain adequate power for the simultaneous operation of all poles and still retain the economy of design, a new automatic oil circuit recloser has been designed which makes use of a shunt operating solenoid. When energized, this operating solenoid closes the recloser and at the same time stores energy for opening. Series trip solenoids are used to release the stored energy to open the recloser when the current exceeds minimum trip value. In addition to the series trip solenoids, the recloser may be provided with a ground current solenoid energized by current transformers connected in series with the recloser. Figure 1 schematically indicates the construction of the automatic circuit recloser equipped with ground trip solenoid and current transformers.

As will be noted, the operating solenoid is connected between two phases of the 3-phase system by means of a snap-action switch. This switch may be closed by manual or remote control of the operating lever to energize the solenoid and instantaneously close the recloser. As the closing stroke is nearly completed, the switch is opened and the solenoid de-energized. The series trip solenoids are coupled through a unique linkage so that at all times only one of these solenoids acts to open the recloser. The opening of the recloser through the trip solenoids may be either instantaneous or retarded in accordance with the selected operating sequence. Approximately 2 seconds after opening operations, the solenoid switch is automatically actuated to re-energize the operating solenoid and reclose the recloser. After the selected number of operations of the recloser, lockout occurs by preventing reclosing of this switch.

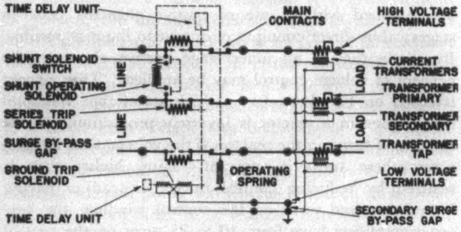

Figure 1. Schematic for 3-phase automatic oil circuit recloser with ground trip solenoid and current transformers

The action of the ground trip solenoid is identical to the series trip solenoids. It functions to extend the time-current characteristics to lower values of trip current. While the series trip solenoids act upon one time-delay, the ground trip solenoid is provided with its own time-delay which is automatically disengaged when the current reaches a value within the range of the series trip solenoids.

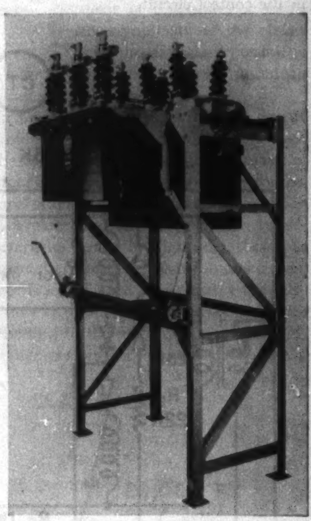

Figure 2. Assembly of 3-phase automatic oil circuit recloser and current transformer mounted on a substation frame equipped with tank hoist

The recloser is made for the normal voltage ratings from 2.4 to 14.4 kv. The maximum full load-current rating is 280 amperes per phase; its maximum interrupting capacity per phase is 4,000 amperes at 14.4 kv, 6,000 amperes at 4.8 kv based upon symmetrical values of currents on circuits with an X/R value of 8. Figure 2 shows the actual construction of the entire assembly mounted in a substation frame equipped with tank hoist.

Digest of paper 52-269, "A New Heavy-Duty 3-Phase Oil Circuit Recloser," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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An Improved Magnetic Servo Amplifier

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ONE OF THE major difficulties in obtaining high performance from a magnetic amplifier servo system has been the slow speed of response of the magnetic amplifier. Although the magnetic amplifier is a carrier-type system and as such has a minimum response time per stage of one cycle of the supply or carrier frequency, this response is usually not obtained in conventional full-wave circuitry. A major factor contributing to the slow speed of response in such circuits is the inductance-resistance time constant in the control circuit.

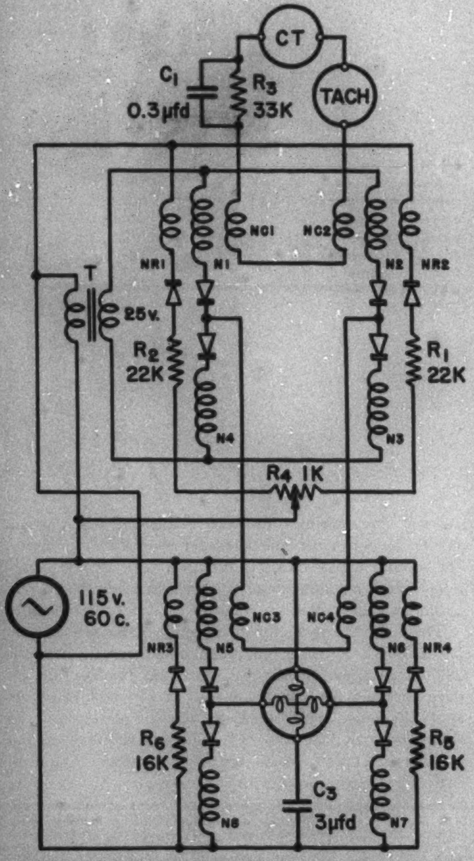

Figure 1. Circuit diagram of a 60-cycle half-wave magnetic servo amplifier

A new magnetic amplifier circuit based on half-wave operation has been developed in which the control circuit inductance-resistance time constant is reduced to an extremely low value and does not contribute to over-all amplifier speed of response. This is possible in this circuit because all the cores which a control winding links are saturated at the same time at some point in each cycle (at the end of the half cycle in which power is delivered). Since the inductance of a saturated core of the material used in this amplifier is very small, transients conventionally occurring in the control current disappear during this period. At the beginning of the half cycle in which the flux is reset, any d-c signal will have reached the full value as determined by the d-c resistance alone, and any cyclic signal will have its steady-state value. The new circuit has been found to operate with the minimum response time, for carrier-type systems, of one cycle per stage, even at high gain levels.

A 2-stage magnetic servo amplifier utilizing the half-wave principle in a bridge circuit arrangement has been developed which gives superior dynamic operating characteristics in instrument-type servomechanism. The amplifier is adjusted for balanced operation by presetting the desired operating flux level in each reactor separately. The fact that each reactor may be adjusted independently or preset to the same reference flux level, regardless of the core's magnetic properties, is of considerable advantage in obtaining balanced operation from cores that normally are too unlike magnetically to be used in the same circuit.

The half-wave bridge arrangement is well suited to coupling or cascading of one stage onto another. This is accomplished without use of passive elements between stages; thus direct coupling of output to input is possible. By elimination of all inner stage passive elements, the concept of voltage control may be applied. This concept is based on Faraday's Law, which states that the total flux change in a reactor is inversely proportional to the number of turns on the reactor, if the voltage time integral across these turns is constant. Thus, higher gain is realized by reducing control turns. Instead of having several hundred turns on the control winding, the new servo amplifiers have from 10 to 25 turns on the control windings of stages following the input stage.

The circuit diagram of a 2-stage 60-cycle half-wave servo amplifier is shown in Figure 1. The 8- and 17-cycle bandwidths obtained with closed-loop 60- and 400-cycle systems respectively, are superior to those obtained using conventional full-wave amplifiers.

Digest of paper 52-235, "An Improved Magnetic Servo Amplifier," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23-27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Automatic Cruise-Control Computer for Long-Range Aircraft

J. R. SHULL

With the range requirements for long-distance flights increasing it is imperative that the operating efficiency of the aircraft be maintained at the highest level. To attain this peak performance an automatic cruise-control computer has been proposed which is here compared with current manual techniques.

THE CONTINUED increase in range requirements for large military aircraft has accentuated the importance of maintaining a high level of operating efficiency at all times. Of particular importance are the increased requirements placed on long-range cruise-control techniques in order to obtain maximum range. At present, flight personnel control the power plant-airframe combination to obtain maximum range during cruising flight by adjusting the power settings according to precomputed data obtained from cruise-control charts. These charts list the power settings to be used in order to realize maximum range under various operating conditions, such as gross weight, altitude, and wind conditions. The power settings, of course, must be periodically adjusted to account for changes in these operating conditions.

Cruise-control charts can be prepared from theoretical calculations or from flight test data. While those prepared from flight test data are more realistic, the cost and time expended in their preparation are tremendous. In either event, the preparation of the charts is usually based on the establishment of ideal airplane duration characteristics. Figure 1 shows the variation in duration characteristic with altitude for a turbojet airplane of a given weight. In general, the duration characteristics of all airplanes have a similar form regardless of the type of power plant installed in the airplane. The cruise-control information obtained from these curves is shown more clearly in Figure 2. Here a typical characteristic for an airplane of a given gross weight and operating at a particular altitude is reproduced. If the power settings are adjusted to give operation at *A*, maximum endurance will be realized, whereas power settings for operation at *B* would allow maximum range to be realized. In addition to the duration characteristics, data from specific fuel-consumption charts, propeller-efficiency charts (in the case of reciprocating engines), speed-power charts, and others are required in the preparation of the complete cruise-control charts.

A very serious limitation to the use of these charts is the fact that any adverse operating conditions (such as icing, enemy attack damage, malfunctions of the power plant or flaps, and so forth) makes the information in the charts in gross error at the very time it is needed most. Additional disadvantages associated with the cruise-control charts include the necessity of periodic manual adjustment of the power settings, the complexity of the charts with the attendant possibility of error, and the large number of charts required to cover normal operating ranges.

An automatic cruise-control system offers a simple solution to these problems. It would eliminate the need for cruise-control charts and would eliminate also many of the manual operations required in present cruise-control techniques. The operation of the automatic system can be explained with greater ease if the airplane range-performance characteristic, shown in Figure 3, is used as reference. This range characteristic can be obtained from the duration characteristic of Figure 2 by plotting the ratio of air speed to fuel flow as a function of engine revolutions per minute corresponding to the fuel flow.

The form of the range-performance characteristic, shown

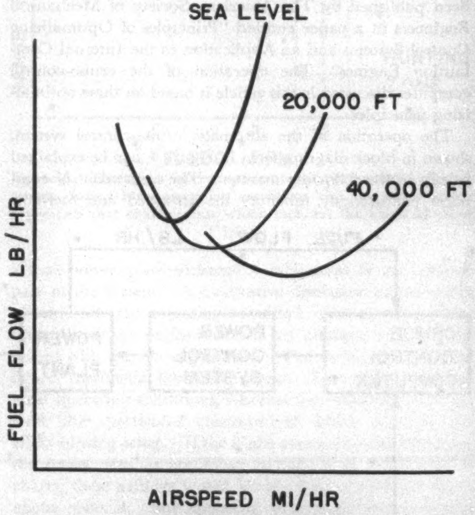

Figure 1. The variation in duration characteristic with altitude for a turbojet airplane of a given weight

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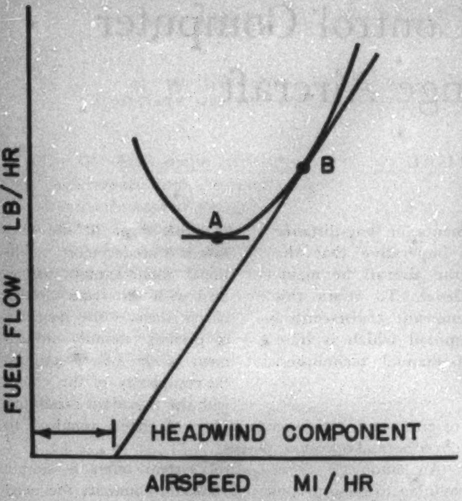

Figure 2. The cruise-control data from Figure 1 are shown here for an airplane of a given weight and operating at a particular altitude. If power settings are adjusted to give operation at point A, maximum endurance will be obtained; if adjusted for operating at point B, maximum range will be realized

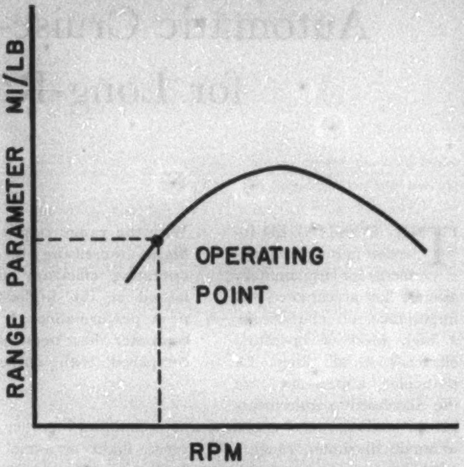

Figure 3. Range-performance characteristic curve obtained by plotting ratio of air speed to fuel flow as a function of engine revolutions per minute

in Figure 3, exhibits the peak required for successful application of optimalizing control to a system. The principles of optimalizing control have been developed and proved by Dr. C. S. Draper and Dr. Y. T. Li at Massachusetts Institute of Technology, and the results of their work have been published by The American Society of Mechanical Engineers in a paper entitled "Principles of Optimalizing Control Systems and an Application to the Internal Combustion Engine." The operation of the cruise-control computer discussed in this article is based on these optimalizing principles.

The operation of the automatic cruise-control system, shown in block diagram form in Figure 4, can be explained briefly in the following manner: The cruise-control computer continuously monitors the air-speed and fuel-flow signals and computes their ratio as the range parameter—miles per pound. By optimalizing control, the computer causes the engine or turbo revolutions per minute to be slowly varied as a function of this range parameter. This revolutions-per-minute variation is constant with respect to time and, as long as the range parameter is increasing, the revolutions-per-minute time rate of change is not altered. When the revolutions-per-minute variation causes the aircraft to pass the peak of the range-performance characteristic and the miles-per-pound signal starts to decrease, the computer causes the revolutions-per-minute time rate of change to reverse so that the peak of the performance characteristic is again approached. Thus the automatic cruise-control system is designed to control the revolutions per minute so that the range parameter approaches and oscillates slowly about the peak of the range-performance characteristic.

For discussion purposes only, the computer will be assumed to be installed in a jet-powered airplane that is characterized by the range-performance characteristic shown in Figure 3, and the initial power settings result in operation at the indicated point. A schematic diagram of the computer mechanization is shown in Figure 5, where a conventional relay servomechanism can be utilized to perform the indicated division. The arrows

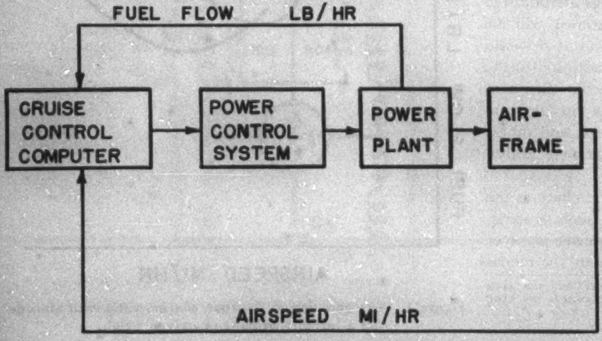

Figure 4. Block diagram of automatic cruise-control system. The cruise-control computer continuously monitors the airspeed and fuel-flow signals and computes their ratio as the range parameter: miles per pound

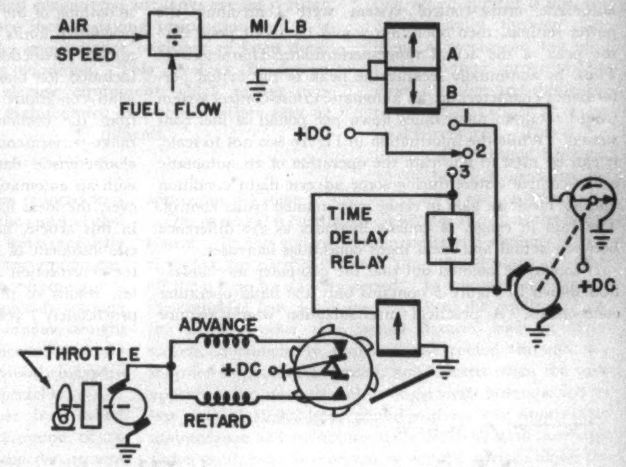

Figure 5. Schematic diagram of the cruise-control computer mechanization where a conventional relay servomechanism is used to perform the indicated division

in the relay coils indicate the direction of contactor motion when the signal in that coil is dominant. The contactor positions shown in Figure 5 indicate that the signals on the two differential relay coils, *A* and *B*, are about equal, and the impulse relay is causing the throttle to be slowly advanced and therefore the engine revolutions to be increased.

Under the foregoing operating conditions the miles-per-pound signal fed to coil *A* of the differential relay will be increasing. As the miles-per-pound signal increases, the differential relay contactor oscillates between positions *1* and *2* and intermittently applies excitation to the d-c motor to drive the potentiometer wiper in a direction to increase the signal on coil *B* of the differential relay. Thus, as long as the miles-per-pound signal is increasing, a reference signal is maintained on coil *B* that is equal to, or slightly less than, the miles-per-pound signal on coil *A*.

When the revolutions-per-minute speed is increased to the point that the range-performance characteristic peak is passed, the miles-per-pound signal starts to decrease. But the signal on coil *B* will remain constant at a value equal to or slightly less than the maximum value which the miles-per-pound signal reached in passing the peak of the range-performance characteristic. When the decreasing miles-per-pound signal allows the reference signal on coil *B* to dominate, the differential relay contactor is moved to position *3*. In this position excitation is applied to the impulse relay coil and to the time delay relay. The actuation of the impulse relay causes the rate of change of revolutions per minute to be reversed, thus causing the system to approach again the peak of the range-performance characteristic. The time delay is necessary because of the time lag of the power plant–airframe combination that occurs between an abrupt change in revolutions per minute and the resultant change in the range parameter—miles per pound. After this time delay, excitation is applied to the d-c motor to cause the reference signal of differential relay coil *B* to be eliminated by driving the potentiometer wiper past the potentiometer excitation terminal to the ground terminal. This causes the differential relay contactor to move abruptly from position *3* to position *1* and the motor continues to drive the potentiometer wiper until the reference signal on coil *B* is equal to or slightly less than the slowly increasing miles-per-pound signal of coil *A*. Thus the system is ready to start another cycle of operation.

The most important advantage of an automatic cruise-control system is the fact that the effects of any adverse operating conditions are included automatically since the actual power plant–airframe combination is an integral part of the system. A qualitative discussion of the effect of some adverse operating condition, such as wing icing, upon the range performance of an airplane will be presented with the aid of Figure 6. The upper curve in this figure represents the performance characteristic during ideal operating conditions, whereas the lower curve represents that particular characteristic which includes the effect of wing icing. If the flight personnel were adjusting the power settings according to data from cruise-control charts, these settings would be adjusted to give operation about point *A*. But operation with these power settings would not allow the maximum miles per pound to be realized as shown by the lower curve. However, if an

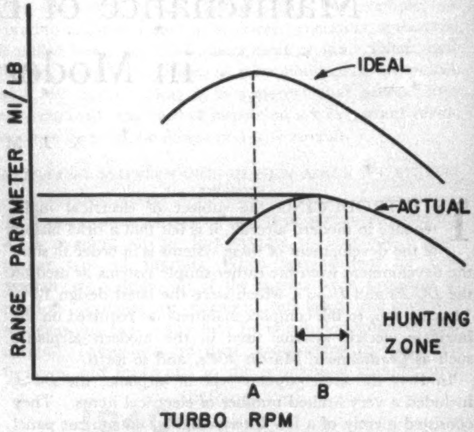

Figure 6. The upper curve represents the performance characteristic during ideal operating conditions and the lower curve represents that characteristic which includes the effect of wing icing

automatic cruise-control system were controlling the power settings, then operation would be about point *B*—the peak of the actual range-performance characteristic. Thus, by continually seeking the peak of the actual performance characteristic, an automatic cruise-control system would result in more miles flown per pound of fuel consumed. While the information in Figure 6 is not to scale, it can be used to illustrate the operation of an automatic cruise-control system during some adverse flight condition and the resultant gain in range over manual cruise control. The gain in range, of course, increases as the difference between actual and ideal flight conditions increases.

It should be pointed out that the computer mechanization shown in Figure 5 contains only the basic operating components. A practical mechanization would require smoothing of the air-speed and fuel-flow signals as well as providing limits on the air speed and revolutions per minute reduction. In addition, provisions could be included for biasing the air-speed signal to account for wind conditions. An important factor to be considered from the economic standpoint is the sharpness of the range-performance characteristic. As the peak of this characteristic flattens out, the gain in range realizable with an automatic cruise-control system decreases. However, the ideas for a cruise-control computer, as described in this article, have had sufficient merit to warrant the establishment of an Air Force development program for the construction and flight test of a prototype unit. The test results of this program should be available in approximately 1 year.

Maintenance of Electric Equipment in Modern Aircraft

A. J. MUSTARD

IN INTRODUCING the subject of electrical maintenance in modern aircraft, it is felt that a brief history of the development of these systems is in order to show the development from the rather simple systems as used on the *DC-2*'s and *DC-3*'s, which were the latest design 10 to 12 years ago, to the complex maintenance required on the intricate electric systems used in the modern airplanes such as *Constellations*, Martin *404*'s, and so forth.

In 1940 the most popular type of airplane, the *DC-3*, included a very limited number of electrical items. They consisted merely of a few interior lights, instrument panel lights, a simple 2-generator regulated 12-volt d-c system, and perhaps a few electric instruments such as tachometers, float-type fuel gauges, and so forth. Today, however, we see the development of air liners in which the electric systems constitute a major portion of the aircraft taking over the work of many of the groups which were previously all controlled either mechanically or hydraulically. In addition, we have many automatic control systems to relieve the load of the flight crew members and to allow them to do their work more accurately and efficiently. Today's airplanes have such complicated electric circuits as autopilots, flux gate compasses, automatic cabin temperature controls, and a number of equally intricate circuits. If these are not designed to the very last word in reduced maintenance, when some system gives trouble it contributes seriously to increased maintenance cost, passenger delays, loss of good will, and other intangibles which are not immediately apparent. No doubt many people on occasion have had what is familiarly known as a delayed departure on some of the country's air lines. Back of this is usually an item of maintenance that required correction and could not be corrected rapidly enough to allow the airplane to depart on schedule. With the increase in electric control systems and electrical items in general, the number of these inconveniences traceable to the electric system continues to increase.

Figure 1 shows a relationship between the electrical units, the number of employees, and the number of aircraft at Eastern Air Lines comparing 1940 with 1952. This will give some idea of the increased importance of electric equipment, electric systems, and their attendant maintenance in the modern type of aircraft compared to those of only 10 or 12 years ago.

THE MAINTENANCE ORGANIZATION

FIGURE 2 shows the shop organization chart and the approximate number of men at Eastern Air Lines involved in each of the several operations, which as a whole constitutes electrical maintenance on the aircraft which are used. It is of interest to note the relatively large number of people involved purely in the overhaul of accessories removed from the airplanes either for time or for failure. This group continues to increase in size in proportion to the other groups of men in this organization.

Full text of a conference paper presented at the AIEE Middle Eastern District Meeting, Toledo, Ohio, October 28–30, 1952, and recommended for publication by the AIEE Committee on Air Transportation.

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Only when commercial airplanes are on regular flights are they a paying proposition and it is up to the maintenance engineer to keep them in flying condition. This involves the design of the electric equipment which makes preventive maintenance and repair either easy or difficult.

The type of people involved in this operation come to the company from several different sources. Their training and experience, of course, is a very important factor in our ability to maintain electric equipment and the installations on the airplanes in such a condition that last-minute failures will be reduced to a minimum. This preventive maintenance is the aim and goal of all operators of aircraft in all departments, but is especially true in the case of the maintenance of electric equipment. Most of the men in our shops have come either from some of the many electrical training schools or aircraft training schools in various parts of the country or have come straight out of high school and through our apprentice training program which, after 4 years, qualifies a previously inexperienced employee for the rank of electrical specialist.

In addition to this training, a further item which increases our efficiency is the high background of experience of the supervisory personnel in the department. In our Electrical Department the general foreman, the foreman, or anyone in supervisory ranks started at the bottom with Eastern, either as an apprentice or as a lowest grade mechanic, and worked his way to the top. The average experience of the men in the foreman's rank and higher is 12 years or more with Eastern, plus any experience he may have had before joining this company. While the background of experience of most of these men is rather good, the original design of systems and components should be such that an inexperienced man can trouble-shoot a system without too much undue confusion and time-consuming effort.

HOW PREVENTIVE MAINTENANCE OPERATES

LIKE ALL other fleet operators whether air line, trucking, busses, and so forth, we operate on a routine schedule of maintenance of all equipment including electric. These periodic inspections grow from a routine check to determine that all equipment is operating normally through the hours of service on the airplane, getting progressively more complex and thorough to the point at which an overhaul is required. This point in our case is around 8,000 to 10,000 hours of operation, or approximately some $2^1/_2$ to $3^1/_2$ years of routine flying.

Our overhaul is conducted on what is known as the block system. In this system, certain units and sections of the airplanes are overhauled each time the airplane is taken off the system for a 5-day period. In following through in the course of four 5-day periods, all of the equipment on the airplane other than actual fixtures, such as lamp sockets, is completely removed and routed through the shop for inspection, overhaul, and discard when the unit appears to be unserviceable. Some units are expected to last the full 10,000-hour period without any appreciable maintenance and are not normally removed until overhaul. Other equipment is removed at varying periods along the line, depending on the type of unit. For example, all rotating equipment, such as inverters, generators, or starters, is pulled out every 1,000 hours more or less. Often used heaters, control amplifiers, or micropositioners, are pulled at 1,550 hours. Thus it is apparent that accessibility, easy removal, and ease of inspection are important maintenance items in the design of a new aircraft.

REDUCING MAINTENANCE IN NEW AIRCRAFT SYSTEM DESIGN

MAINTENANCE, of course, begins or is reduced from the moment an air line decides to purchase a particular type of aircraft. When specifications for new aircraft are written, all of the maintenance problems in previous airplanes are organized, tabulated, and reviewed to determine how many may be eliminated from the new design. These lists are then incorporated in the specifications and forwarded to the prospective manufacturer

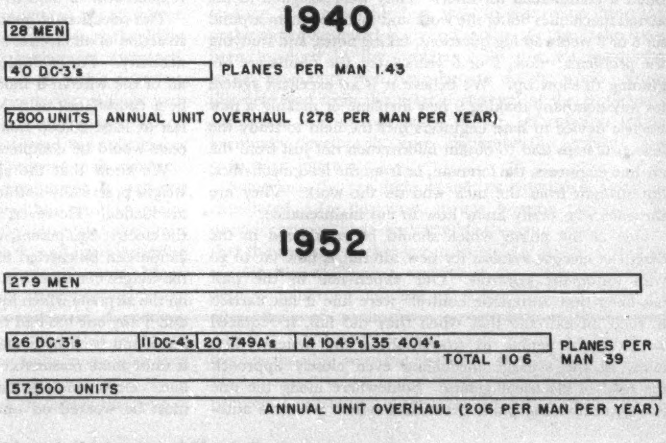

Figure 1. This relationship between the number of workers, the number of aircraft, and the number of electrical units at Eastern Air Lines in 1940 and 1952 will give some idea of the increased importance of the electric systems and their attendant maintenance

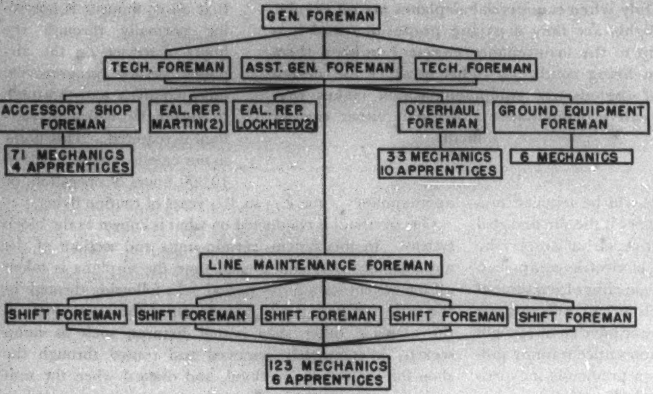

Figure 2. The electrical maintenance, radio, and instrument line maintenance organization chart at Eastern Air Lines which shows the relatively large number of personnel involved in the overhaul of accessories removed from airplanes either for time or failure

and the representatives appointed by our air line to represent us during the design, development, and manufacture of the aircraft involved in order to obtain as low a maintenance factor as possible on the aircraft being purchased.

When a new aircraft is being designed for sale or delivery to an air line, proper insight into the problems involved in the maintenance of the aircraft after it has been delivered will reduce very appreciably the maintenance problems and attendant costs. While we are attempting not to use any manufacturers' names in this article, we do wish to draw attention to the excellent field representation which the Martin Company sent from all of their departments before the original design of the Martin *202*, which has indirectly reduced our maintenance cost on the present *404* airplane. Many of the ideas gleaned by these engineers while in contact with the air lines were carried through into the *404*'s and we expect will be carried through on any future air liners that the Martin Company designs. In this case, engineers were sent into the field more than a year in advance of the time the Martin Company proposed to build a commercial air liner. They were assigned to the actual mechanics doing the work and followed them around for 6 or 8 weeks asking questions, taking notes, and studying the problems; now, 5 or 6 years later, the results are beginning to show up. We believe it is an excellent system for any company making a new airplane or making a new electric device to send engineers into the field to study the field problems and to obtain information not just from the air-line engineers, the foreman, or from the lead mechanics, but straight from the men who do the work. They are the ones who really know how to cut maintenance.

One of the points which should be considered in the design of electric systems for new aircraft is how far to go with automatic controls. Our experience in the past has been that automatic controls were fine if not carried to such an extreme that when they did fail, it required an electrical genius to trouble-shoot the system. Not many of the average mechanics even closely approach the field of electrical genius. Somewhere along the line is a good dividing point between a system which is automatic enough and yet not too automatic. When in doubt, the aircraft system design engineer is advised to favor the less automatic as it will be the most troublefree and require the least maintenance. We realize that in many companies the electrical engineer is treated as an "orphan" in so far as space and accessibility to their equipment is concerned. However, they also are called upon to be the "fair-haired boy" when the time comes to solve an intricate problem. This leaves them in a position of having to produce a solution to a problem and then having to bury the equipment which solves the problem in some out-of-the-way point where it is totally inaccessible for maintenance. When this is the case, the original problem might not have been as bad as the problem of trying to service and maintain the electrical solution. Just because electrical items are small in size and usually easily mounted in practically any position, do not "bury" them. Maintenance can be appreciably reduced if the equipment is not buried but is equipped with disconnect fasteners, anchor nuts instead of blind nuts, and similar methods to make rapid replacement of defective units possible.

The selection of good materials to be used in the construction of all electric systems in the aircraft is an absolute necessity. For example, consider the problem of replacing all of the wire in a modern aircraft—some 18 or 20 miles in a *Constellation* or a Martin *404*. If this wire does not last at least 20,000 hours (6 or 8 years) the maintenance costs would be completely out of reason.

We know that the air lines expect an airplane which weighs practically nothing until the passengers and gasoline are loaded. However, in order to reduce maintenance on the electric equipment, weight consciousness and miniaturization can be carried to too great an extreme. If we are too weight conscious we may end up with an electric system on the airplane which approaches in design a portable radio and if any one has had to work on one of these, he probably has found it cheaper and easier just to put off working on it until some reasonable excuse comes along to buy a new one. Unfortunately, airplanes are not disposable and must be worked on under pressure of time and climate, so the aircraft manufacturer should keep in mind that the maintenance man will have to maintain the equipment after it has been designed and built into the airplane. Even for the sake of reduced weight we should not design down to something that cannot be worked on.

DESIGNING REDUCED MAINTENANCE INTO NEW AIRCRAFT EQUIPMENT

Everything that has been said for new aircraft systems is usually applicable to the manufacturers of equipment for aircraft with the addition of a few other factors.

When a sales engineer from one of the equipment manufacturers arrives in our office with an item for sale for new aircraft, they consider they have the last word in that particular type of equipment and usually are very proud of the fact that the expectant service life of the unit falls within the Army-Navy (AN) specifications. Most readers are undoubtedly familiar with the AN specifications for the items they manufacture and the fact that the service life required to pass these specifications is rather low. Of course, in the military, absolute schedules need not be maintained. Adequate spares, except in time of extreme emergency, are always available in large numbers and speed of replacement is not usually a very high governing factor. For some reason, when a General wants to go somewhere, there usually is an airplane in good shape parked away behind the hangar waiting for just such an occasion—while in an air-line operation the airplanes must be kept flying to make money so that we can continue to purchase new equipment, provide better service, and progress. This means equipment which can be installed and under reasonable conditions can be expected to last until predetermined overhaul periods for the equipment without an undue percentage of unscheduled removals.

All units and control equipment designed for aircraft should be designed for reasonably rough service not only from a mechanical standpoint due to vibration and shock in the airplane, but also to be foolproof against incorrect manipulation on the part of the flight crews and maintenance men. Wherever possible, the systems and equipment should be interwired in such a manner that improper sequence of operation can do no damage to the equipment. If you realize the strain and preoccupation of the flight crew members when in a difficult instrument approach, you will realize that unless steps are taken in this direction, often the wrong switch is thrown and you end up with another maintenance problem on your hands. Rough usage and handling should be considered the rule rather than the exception in designing for reduced maintenance.

Since in aircraft installations, equipment is not just installed and allowed to run forever but must be maintained and overhauled at periodic intervals, the units should be designed in such a manner that all parts requiring inspection or adjustment should be out in the open. Many of the pieces of equipment which we have received in the past, while they were electrical wonders in themselves, only served to produce mechanical headaches when attempts were made to service these units even after they were removed from the airplane and were sitting on a work bench in the shops. In order to reduce this type of unnecessary difficulties, we plead with the equipment manufacturers to submit new designs to actual air-line mechanics and let them write up what they find that makes the unit impossible or difficult to service and overhaul. Eastern Air Lines shops are always available to electric-equipment manufacturers to receive comments on their equipment, even though we are not in a position of being ready to purchase the particular equipment at that time. We might want exact equipment sometime in the future and we do not wish to be "stuck" with something we cannot work on no matter how well it functions. Above all, electric equipment for the aircraft should be designed so that with proper maintenance, it shall be absolutely safe and in case of failure, it will fail in what will be considered a "fail-safe" position. You too fly; keep this in mind when you design equipment.

REDUCING MAINTENANCE COSTS AND INCREASING RELIABILITY IN OPERATING AIRCRAFT AND EQUIPMENT

After an air line receives the equipment and aircraft which are no doubt the pride and joy of the design engineers, for some reason we continue to have problems. These problems, of course, in order to operate economically must be reduced or eliminated and in order to accomplish this end they first must be detected. This, of course, is often not too hard as the troubles occur on a daily basis and the line forms on the right for people wanting a solution for the problem. Other problems, especially those of inconvenient maintenance, must be detected through the form of employee's suggestions, study of delay summaries, study of unscheduled removals, and so forth.

After they have been detected, the trouble must be cured. By far the most effective method of curing these troubles is to eliminate the trouble-making devices wherever practical either by the substitution of new or improved design units, or by the actual complete elimination of that particular item where not absolutely essential to the operation of the airplane or to passenger comfort and safety. Where the problem cannot be completely eliminated, cures must be worked out. We find that as maintenance engineers, the best way to determine how the problem can be cured is go and talk to the men who have been involved in the problem. By this we mean the actual mechanics who have had to do the work. From this field and from the normal channel of the employee's suggestion, we receive much of the information which eventually develops the cure, eliminates the problem, and reduces maintenance.

Sometimes the problems cannot be completely cured or eliminated. In this case, it has become necessary to provide proper tools and trouble-shooting equipment so that the average mechanic can locate the problem, change the defective equipment, and return the airplane to service with a minimum amount of delay. Special tools are often designed to improve accessibility of these units. At other times when a complicated system is involved a trouble-shooting test unit, which we familiarly call "little black boxes," is the best solution to the trouble-shooting problem. Wherever these units can be designed to do some of the mechanic's thinking for him, we have developed such units. This is especially true on intricate systems such as cabin temperature control and fire-detector systems. Often, unknown to us, the manufacturer of the equipment actually has units available at his factory which do this job. We feel that whenever any such equipment is available, the manufacturer of the equipment should feel obligated to make this information available to the people who use the equipment. It not only should be his obligation but a good sales point that such equipment is available and by making equipment and information available, the men who have to service the equipment could prevent his particular product from receiving a bad name in the industry. Many times the reason the manufacturer's product is run down by the Maintenance Department of an air line is that they do not have sufficient information available to service the equipment properly in the first place. At this point, the maintenance engineer from the air line comes in to solve the problem.

THE MAINTENANCE ENGINEER'S PART IN AIRCRAFT ELECTRICAL MAINTENANCE

When problems arise where maintenance costs are too high or when too many people are being inconvenienced by delay schedules, the maintenance engineer comes into the picture of electrical maintenance, takes over the problem, and arrives at an eventual solution. This may be a cure which can be worked out totally within the air-line organization and then again it may be an item which has to be handled and discussed either with the equipment manufacturer or with the basic airplane manufacturer. In such a case, the maintenance engineer handles all the correspondence, contacts the field representatives of the manufacturer, or visits the manufacturer's plant and discusses the problem with the engineers, until a successful cure is formulated. If the problem can be cured within the air line's own organization, the maintenance engineer prepares a survey of the preliminary details which will be required to change or repair the existing installation to eliminate the problem. After a cost survey, if the expenditure to cure the problem is justified by the size of the problem being cured, the engineer prepares the final details, determines the exact parts required, and produces the engineering release or engineering order which indicates the cure. Should any problems arise during the processing of the job, it is the engineer's responsibility to determine their cause and to solve them.

From the day an air line decides to buy an airplane, however, the maintenance engineer begins to enter the picture. It is his responsibility to: (1) prepare the specifications for the new aircraft with the ideas in mind of utilizing equipment and parts which are already inventory items; (2) provide the details necessary to insure that these parts are used in such a manner that any removable item is interchangeable between different models and different manufacturers' airplanes; and (3) discuss with the aircraft manufacturer the reasons behind items in the specifications, help him with solutions to interchangeability problems and, in general, have the airplane delivered ready for immediate integration into the fleet.

It is also the duty of the maintenance electrical engineer to provide accurate, up-to-date, easy-to-read standardized wiring diagrams and other service aids to reduce the maintenance man's efforts in servicing and trouble-shooting faulty installations. In the past, not enough emphasis has been placed on simplified standardized electric wiring diagrams. At Eastern, for the past 4 or 5 years, we have been attempting to make each diagram which we issue of such a standardized form that the mechanics can determine immediately from the diagram the areas of the airplane in which certain items are located, the part numbers of the items in our stock, and in general, the flow of continuity or electrical actions within the circuit. These diagrams are then especially helpful to the mechanic or electrician who does not often work on a particular circuit, in enabling him to analyze and trouble-shoot the circuit with a minimum amount of wasted effort and wasted time.

ITEMS WHICH THE INDUSTRY NEEDS

It is our feeling that we should take this opportunity to define some of the items which we need to reduce maintenance and increase the efficiency of aircraft operation. We may find that some of the items are already manufactured or that at least we can interest some of the manufacturers in developing items of this type. Perhaps they are available already and we just never have come in contact with them.

First, we need a good, attention-attracting, a-c power-failure indicator which will give readily visible warning that a 3-phase a-c power system has stopped delivering power to the flight instruments. This unit would be expected to show a failure of power on any leg of the 3-phase system and also would show when a mechanic had connected the system in such a manner that the phases are not in proper rotation. The unit would have to be of such a design that it did not in itself present appreciable jeopardy to the circuit involved. It probably would be called upon to light a warning light in case of a-c power failure.

Another item which is still not to the point of complete satisfaction, is the item of circuit protection such as fuses and circuit breakers of the smaller variety for protecting individual lights and other circuitry. A thermal circuit breaker, in most cases, is too slow to interrupt an intermittent electric short circuit. The same applies to conventional fuses and especially to fuses which are rugged enough to stand up in aircraft service. This circuit protection should be in the form of a unit which would handle reasonable overload such as inrush current, but would instantaneously disconnect on a high-current fault on the order of five to six times the rated capacity. One or two circuit-breaker manufacturers already are working on this problem. We certainly hope they are successful as such items are vitally needed.

Over the past several years, many wire manufacturers have worked on the problem of fireproof wire. To date, most of these wires, while good in some particular respect, are faulty in others. The industry vitally needs a fireproof wire which will stand up under abrasion, soaking in common aircraft fluids, withstand fire, and in general be comparable in service to the normal cotton-covered military specification wires. Some of the wires presently available almost meet this desire. We hope development will continue.

Closely associated with fireproof wire is the problem of fireproof electric connectors to meet the Civil Aeronautics Administration (CAA) requirements for firewall connectors at the engine attach points and still give long rugged service. We do not believe that any of the plug manufacturers can claim that the connectors developed to date really meet these requirements. If any of these manufacturers really believes he has plugs with insert materials which meet this requirement, we would like to contact him as this constitutes one of our very bad maintenance problems at this moment.

One of the needed items which, while rather insignificant in appearance, produces a nasty maintenance problem, is that item commonly classified as warning lights. While the present warning lights made by several manufacturers all give good trouble-free service, they are all difficult to replace and difficult to remove when equipment must be overhauled, as to the best of knowledge they are all soldered in types. We need a warning light with a good single connection quick disconnect.

Another item which appears rather insignificant but produces a severe maintenance problem is that of a dual-filament lamp for top fuselage lights which will meet the latest CAA specifications as to brilliance. In the past, we used a dual-filament 21-candlepower lamp in this location with a change-over switch inside the fuselage which eliminated the necessity of the mechanics climbing on top of the fuselage at an intermediate stop where proper stands were not available to change lamps. If you can picture the mechanic working to change a lamp under pressure on an icy fuselage with improper equipment, you can see the severe need for a lamp to fit this location.

The foregoing are just the items which are in mind today, and are needs of the industry. We hope that by a few months from now, some or all of the problems will be solved. Unfortunately, no doubt others will arise from time to time, but by proper co-operation between the air lines and the manufacturers, we feel that these problems need not go on for extended lengths of time as they have in the past.

CONCLUSIONS AND RECOMMENDATIONS

To provide improved and efficient maintenance is the goal of all employees of the air lines. It should be and is becoming an increased goal for aircraft and equipment manufacturers. The trend should be continued and amplified until all aircraft and aircraft equipment produced are at least reasonably free from maintenance problems and reasonably easy to service when failures do occur. By these means we can continue to reduce costs so that in spite of inflation we continue our policy of supplying economical transportation.

As a further aid to improved maintenance and better service to the flying public, we should encourage young men to enter the field of aircraft maintenance and aircraft engineering. In so far as aircraft maintenance is concerned, most of the air lines support efficient apprentice training setups where young men can learn an interesting, well-paid trade in a field which even today, we all believe, is still in its relative infancy and one which in the past has been well known for its chances for advancement. We also should encourage electrical engineers who are working for their engineering degree to look towards the aircraft industry as a future employer and include in their studies at least a reasonable amount of aeronautical engineering, as many of the problems of the electrical maintenance engineer enter quite widely into the aeronautical field.

The aim of all of us in the maintenance field is to produce a safe, reliable, scheduled, rapid means of transportation. We hope that this can be aided by good, efficient maintenance and simplest possible design.

Single-Tone Selective Signaling System

A dependable, single-tone selective signaling system has been developed by Motorola, Inc. The new system has been designed for use in conjunction with any communication medium, 2-way radio, land lines, microwave or power-line carrier, anywhere that remote control or receiver selection is a necessity.

The function of the system is to allow any operator to initiate an operation at one or more remote points through an intervening communication medium. The operation may be the selection of a particular receiver or group of receivers from many receivers in a system, the selection of a particular relay transmitter, the illumination of a particular lamp on an indicator panel, the sounding of a particular alarm, any operation that can be remotely controlled by a relay.

There are four basic components to the single-tone system: the 10-button selector box, the single-tone oscillator, the 3-frequency switch kit, and the single-tone decoder.

The 10-button selector box, ordinarily used at a fixed station, contains an oscillator and 10 tuned circuits. Each button is associated with a different tuned circuit and connects the circuit to the oscillator, causing a fixed frequency tone to be generated. The single-tone oscillator generates only one tone in the same manner as the 10-button selector box and can remotely control operations. The 3-frequency switch kit is used to adapt the single-tone oscillator for 3-frequency operation. The single-tone decoder contains a relay which operates when the tone to which the decoder is tuned is received. The decoder contains the differential selectivity circuit which is the key to the successful application of the system since it prevents accidental triggering of the decoder by nearby frequencies, harmonic, or voice tones.

Sleet-Melting Practices: Niagara Mohawk System

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EXPERIENCE WITH SLEET CONDITIONS on the Niagara Mohawk System has indicated that adequate planning is necessary if satisfactory results are to be secured from any sleet-melting program. This planning extends from system design, to operating procedures, to training. All must be co-ordinated to weather a severe storm successfully. Included in this planning is close contact with the United States Weather Bureau.

During the course of any sleet storm there is usually a period of moderate temperature and little wind when sleet-preventing or -melting procedures are most effective. Prompt action at this time may save hours of work later or possibly a system calamity. Older melting procedures were cumbersome and time consuming so that it was often impossible to take advantage of the favorable period for sleet prevention or melting.

Some years ago Niagara Mohawk recognized the shortcomings of the then existing sleet-melting program and initiated studies to improve the situation.

Tables were to be developed showing required sleet-preventing or -melting currents for conductors under varying weather conditions.

A-c network analyzer studies followed, to determine system setups most adaptable for sleet-melting purposes. In some cases these studies indicated that changes in normal system connections would be advantageous.

Co-ordination of the afore-mentioned studies resulted in the following:

1. The Niagara Mohawk System recognized three principal methods of sleet prevention or sleet melting which are:

    A. *Load Current Method.* The heating effect of load currents is used to prevent or remove ice on the conductor. Where necessary, normal operating conditions are modified in order to force more load current through a particular circuit or circuits.

    B. *Short-Circuit-on-a-Generator Method.* One or more generators are isolated from the rest of the system and connected to a circuit, which also has been isolated and short-circuited at the far end. Generator field is gradually increased, from a subnormal value to a value sufficient to produce the desired melting current.

    C. *Short-Circuit-on-a-Bus Method.* One or more transmission circuits are isolated from the rest of the system. The total length of the transmission circuits is predetermined so that, with normal operating voltage applied at one end and a 3-phase short circuit established at the far end, the desired sleet-melting current will flow. Then, having established the 3-phase fault, the near end is connected to its regular bus, at normal voltage, through a circuit breaker.

2. System connections were changed as indicated by the a-c network analyzer studies.

3. Step-by-step instructions and detailed drawings were developed for the various sleet-melting procedures.

Included in the instructions and material for use by the operating personnel are the "Sleet-Melting Tables for Overhead Electric Power Conductors." These tables actually include "conductor safe ampere limits" and "sleet-preventing amperes" for a suitable range of air temperature, wind velocity, and conductor size, and "sleet-melting amperes" for a suitable range of air temperature, wind velocity, ice thickness, melting time, and conductor size.

Conductors maintained at a temperature slightly above freezing will not become coated with ice. Once ice has formed on a conductor it is necessary to employ sleet-melting currents, which will be greater than sleet-preventing currents. A comparison of any two corresponding sleet-preventing and sleet-melting currents, that is, before and after ice has formed, emphasizes the importance of acting before conditions become unfavorable. Data for 350,000-circular-mil copper conductor taken from the tables are as follows:

Air Temperature (Degrees)	Ice Thickness (Inches)	Wind Velocity (Miles Per Hour)	Melting Time (Minutes)	Current Required (Amperes)
Sleet Prevention				
30	0	2		146
Sleet Melting				
30	0.1	2	50	245
25	0.1	10	30	420
20	0.5	20	30	800

As much of this program was new, it seemed desirable to acquaint operating personnel with procedures. As a training program, several of the sleet-melting connections were actually set up on the system and melting currents were applied for short periods.

Since the adoption of this program, several light sleet storms have been weathered without disrupting the system. The procedures which have been developed have worked successfully under conditions that normally would have caused trouble.

However, further experience with storms where heavy ice formations accumulate will be necessary before the program can be fully evaluated.

Digest of paper 52-188, "Sleet-Melting Practices; Niagara Mohawk System," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Power-Line Carrier System Line Traps

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THE PROPER application of line traps in power-line carrier systems requires the consideration of the needs of the system and the properties of the line traps. In the past, insufficient information was generally given or, in many cases, known, to realize the possible resonant conditions that could exist in an installation. Recent investigations have brought to light many of these pitfalls.

Line traps are used to insert additional impedance at carrier frequencies in a line. This impedance may be desired to prevent solid grounding of the carrier signal during some fault conditions for carrier relaying, or the impedance may be desired to reduce the attenuation due to the signal reaching a bus and being divided among the several lines terminating at the bus. Because of these uses for line traps, the general feeling has been "the higher the impedance, the better the trap." As a result, comparatively high-Q line traps have been universally used. When keyed carrier operation is desired, the carrier having no modulation at any time, it is acknowledged that an extremely high-Q line trap is desirable. However, when a band of frequencies such as a modulated carrier occupies is used, then the trap impedance across the band of frequencies used must be considered.

Only the carrier-frequency characteristics are to be considered here. The power-frequency and mechanical characteristics are considered of minor importance in so far as the carrier-frequency operation is concerned.

1. *High-Q Line Traps.* The general characteristics of line traps are expressed in a variety of ways. However, the presently available low-inductance (less than 0.5 millihenry) high-Q line traps, irrespective of the manner of stating their characteristics, are essentially the same. The line trap has a minimum of 400 to 500 ohms impedance at ±5 per cent off of the resonant frequency over the band of 50 to 150 kilocycles. The maximum impedance at the resonant frequency is quite high. Usually not stated, but of interest, is the value of Q which is in the vicinity of 75 or 80. It must be remembered that for a 2-frequency trap, the maximum impedance at each of the two resonant frequencies is approximately one-half that of the same line trap tuned for a single frequency.

This type of line trap is ideally suited to narrow band channels. This includes keyed carrier for relaying telemetering, supervisory control, and any of the other on-off functions when operated on a keyed carrier channel. This trap is also applicable for 1- or 2-frequency shift type of channels when utilized for any of the foregoing intelligence functions. Since the impedance varies quite radically over any appreciable bandwidth, the losses can vary considerably. This can cause attenuation of sidebands if this type of trap is used for trapping a modulated carrier. If the termination behind the line trap happens to be essentially reactive and of the proper magnitude, part of the reactive component of the trap can be effectively cancelled. This increases the attenuation even more over a portion of the desired sideband.

2. *Low-Q Line Traps.* The low-inductance low-Q line trap has a lower maximum impedance at its center frequency than does the high-Q line trap just considered. Due to the lower impedance at center frequency, the attenuation of the center frequency signal is higher than that of a low-inductance high-Q line trap. The advantages of a low-Q trap of this type is the broad-band impedance and resistance characteristics. At the ±5-per-cent frequency points, the impedance has decreased to about 0.7 of the center frequency impedance and the resistive component has decreased to about 0.5 of the center frequency resistance as compared to 0.13 and 0.016, respectively, for the high-Q line traps.

The advantage in using the lower Q inductance is that the resistive component of its impedance at ±5 per cent or less is sufficiently high so that the reactive characteristics of the device, bus, or line behind the trap will not appreciably affect the performance of the trap. In many installations the trap termination is reactive in nature and under certain conditions series resonance of the line trap and its terminating equipment just off center frequency can cause severe loss of signal unless a sufficiently large resistive component of impedance is available in the trap.

From the characteristics of the line traps, both high and low Q, the following conclusions can be drawn:

1. Line traps should have a low ratio of resistance at resonance to resistance away from resonance for the desired bandwidth.
2. A considerable improvement in percentage modulation or effective frequency deviation will result with low-Q line traps.
3. Loss of sidebands due to resonant conditions will not be as severe with low- as with high-Q line traps.
4. Trapping of each frequency-shift channel is more uniform for a group of frequency-shift channels operating adjacent to one another with low-Q traps.

It should not be inferred that a low-Q line trap should be used in all applications. The high-Q line trap has very definite advantages in narrow-band applications, such as carrier relaying, and should be considered in these applications. By judicious consideration of trap requirements and trap characteristics, the optimum trap performance can be obtained.

Digest of paper 52-275, "Application of Line Traps to Power-Line Carrier Systems," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Ind

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South India now has a larger high-voltage laboratory at Bangalore which will facilitate basic research, train personnel in high-voltage technique, and carry out electrical tests for industry and science. A brief description of its equipments and the types of investigations undertaken are presented.

ANOTHER high-voltage laboratory has been completed at the Indian Institute of Science, Bangalore, South India. An outside view of the laboratory is shown in Figure 1. The whole building is constructed of massive granite locally quarried. It is the natural development from its predecessor which was established at the Institute in 1926. This small high-voltage laboratory was at that time sufficient to meet the needs of the electrical industries and power supply companies. It has contributed its share in the development of the Government of Mysore electrical porcelain factory and the Government transformer factory in Bangalore.

With the increasing use of higher voltages for transmission lines it was necessary to provide increased facilities for research and the training of personnel in high-voltage technique. The funds for establishing the new laboratory were allocated by the Government of India and the foundation stone for the building was laid in February 1948. The high-voltage laboratory building was opened by the President of the Union of India, Dr. Rajendra Prasad, on April 10, 1951.

The laboratory consists of the main hall 85 by 120 by 93 feet which houses the main high-voltage equipment, four smaller halls on the ground floor adjacent to the main hall, and three smaller rooms each 14 feet high on the first floor. See plan, Figure 2.

The walls and the floor of the hall have embedded in them galvanized steel mesh welded to the steel frame of the roof to provide electrical shielding. Three galleries have been provided at various levels in the hall for observation of the high-voltage phenomenon.

EQUIPMENT

THE MAIN SURGE GENERATOR, Figure 3, rated 3,000 kv, 50 kw (Marx circuit), consists of four columns each 30

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feet high, located on a common base plate (distance between the columns 10 feet) with 30 capacitors, each rated 0.33 microfarad, 100 kv, separated by Textolite cylinders.

Tripping of the main generator is effected by means of second small surge generator. The auxiliary surge generator is tripped by a pulse through a thyratron from the cathode-ray oscilloscope. Any desired wave shape can be obtained from the generator by proper selection of the resistances and capacitances.[1]

A high-voltage high-speed cathode-ray oscillograph is used for observation and photographic recording of high-speed transients. See Figure 4. Its visualizing element is a sealed-off hot cathode-ray tube whose screen may be photographed by a camera and simultaneously viewed by the operator. Accelerating voltage of the tube is 25 kv. The writing speed is approximately 10,000 kilometers per second.

A high-current impulse generator gives impulse currents up to 200,000 amperes. See title picture showing 200,000-ampere 29-kw current surge generator exploding a 16-gauge wire. It consists of 48 capacitors each rated 50 kv direct current, 0.5 microfarad, 28.8 kw. Two shunts rated 50,000 amperes and 150,000 amperes are used for measurements of surge currents with the cathode-ray oscillograph.

For testing at power frequency, three transformers each rated 1,000 kva, 2,300 to 350,000 volts, 50 cycles, are provided which can be used either in 3-phase to produce 660-kv phase to phase, or in cascade to produce 1,050,000 volts to ground. See Figure 5. The high-voltage winding of each transformer has been tapped for the measurement of high voltage (ratio 1:1,000). The a-c voltmeter connected to this winding has to be carefully protected against surge voltages.

A separate motor-generator set consisting of a 300-horsepower synchronous motor driving a 1,000-kva generator supplies a pure sine wave. They are housed in a separate room to prevent transmitting of vibration or noise to the main hall.

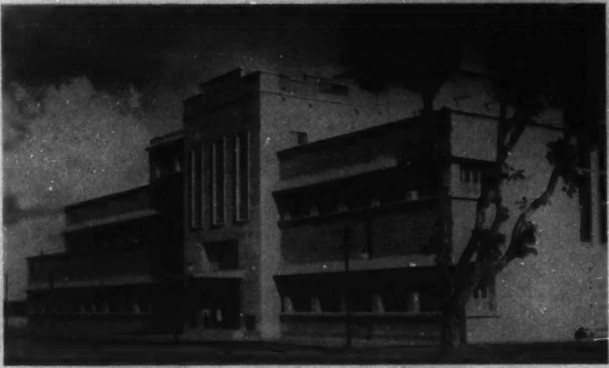


Figure 1. High-voltage laboratory, Bangalore, India

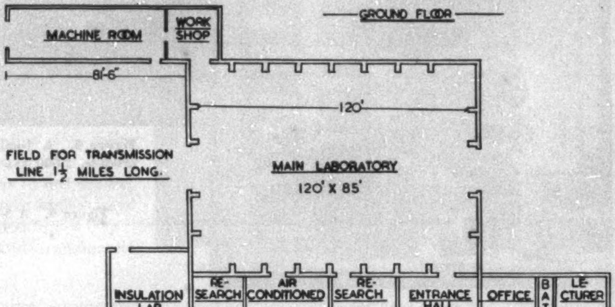

GROUND FLOOR
MACHINE ROOM
WORK SHOP
81'-6"
120'
FIELD FOR TRANSMISSION LINE 1½ MILES LONG.
MAIN LABORATORY
120' X 85'
INSULATION LAB
RE-SEARCH
AIR CONDITIONED
RE-SEARCH
ENTRANCE HALL
OFFICE
BATH
LECTURER
218'-6"
I-FLOOR
OPEN TERRACE
130'
VISITOR'S GALLERY
TERRACE
RE-SEARCH
DARK
RE-SEARCH
STORE
LIBRARY
UP
STAIRS ROOM
DN
ASST. PROF.
BATH
PROF.

Figure 2. Plan of high-voltage laboratory

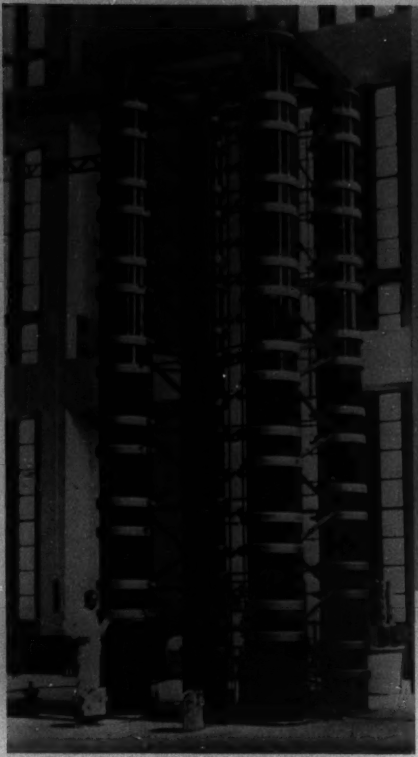
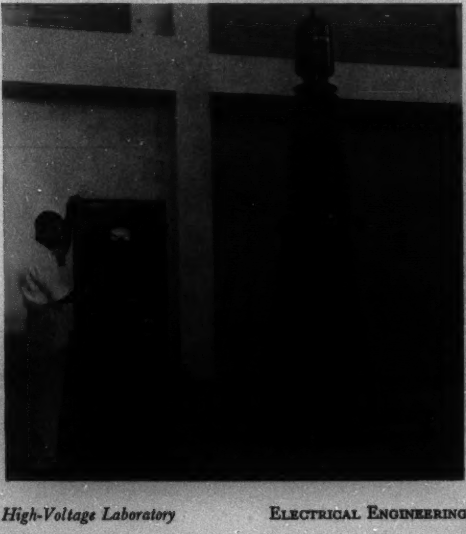


Figure 5. A 1-million-volt a-c test set, three transformers in cascade, 1,000 kva flashing over a string of insulators (above)

Figure 3. A 3-million-volt surge-generator, 50 kw (left)

Figure 6. High-voltage Schering bridge with built-in amplifier and 300-kv standard capacitor (below)

Figure 4. High-speed cathode-ray oscillograph



For high-voltage measurements of power factor and capacitance of insulating materials and high-voltage equipment, a standard gas-filled capacitor 0.0001 microfarad rated 300 kv is available. It will be used in conjunction with a Schering bridge with an amplifier null detector. See Figure 6.

A Kenotron set provides 0.025 ampere at 250 kv and is placed in one corner of the main hall. See Figure 7. It is provided with oil-immersed resistors for the measurement of the voltage.

A repeating surge generator, 50 surges per second, 210 kv, is provided. See Figure 8. The voltage and current waveforms can be viewed and measured in a cathode-ray oscilloscope.

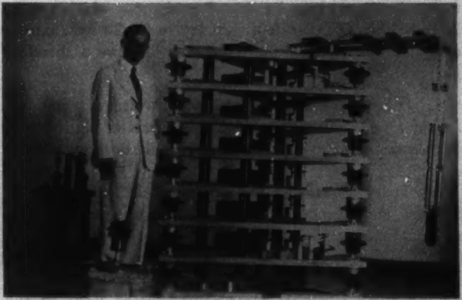


Figure 8. A 210-kv repeating surge generator, 50 surges per second

A sphere gap with spheres of 2-meter diameter measures the high voltage above 500 kv; under 500 kv electrostatic and crest voltmeters are used.

Pumps, storage water tank, and nozzles rack are available to conduct tests under artificial rain of any conductivity according to various specifications.

The European experience with high-voltage laboratories furnished with artificial light only has revealed the disadvantages of windowless halls. The windows of the main hall on one side are therefore provided with motor-operated dark blinds and the windows on the other sides are shielded by curtains. The recording of corona in this darkened hall is shown in Figure 9.

Figure 9. Corona and arc over a string of insulators

A flexible experimental transmission line $1^1/_2$ miles long suitable up to 380 kv is under construction. Three big openings, one 20 feet square and two 10 feet square, covered by rolling shutters are used to take high-voltage leads from the main hall to the transmission line.

One of the smaller halls houses three cascade transformers 10 kva each to deliver 330 kv. It has a Schering bridge with an air capacitor for 100 kv.

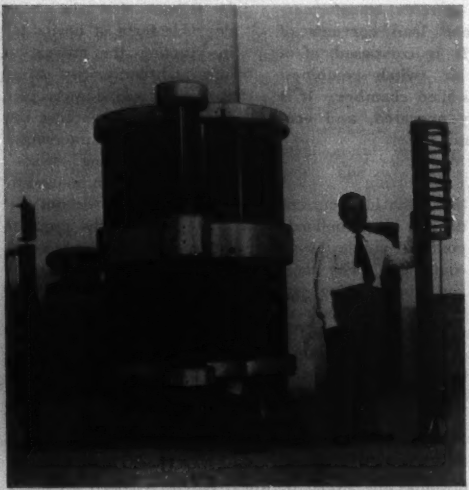


Figure 7. A 250-kv 25-milliampere d-c test set with potential divider

For testing insulating materials special conditioning ovens are provided and instruments are available for measuring the dielectric constant and power factor from 50 cycles to 5 megacycles. For testing high-voltage equipment under conditions of heat and ice one of the rooms of the high-voltage laboratory, dimensions 20 by 20 by 20 feet, is air conditioned. Any temperature between −6.5 and 60 degrees centigrade and relative humidity between 60 to 100 per cent can be adjusted and automatically controlled within narrow limits. High voltages from the main hall can be led into this room through a special glass bushing.

One hall is permanently air conditioned, 20 degrees centigrade and 60 per cent relative humidity, for calibration and standardizing work.

The laboratory has its own small workshop, photographic facilities, enlarger, microfilm reader, and so forth. Most of the equipment is of the latest American design and has been supplied by the General Electric Company.

This laboratory is the largest of its kind in India and southeast Asia. The main hall has plenty of space for testing large test samples, heavy equipment which can be brought through two doors, 20 by 20 by 20 feet, on the east and west sides of the hall. It will serve a threefold purpose:

1. It will train students in high-voltage technique. Lectures will be given on various subjects of high-voltage engineering and experimental work will be done by the students.
2. The laboratory will carry out electrical tests for industry and science. All high-voltage tests according to specifications on Indian-made or imported high-voltage gear now can be made satisfactorily.
3. The laboratory will conduct basic research. The staff of the laboratory has already started work in the following branches: Development of an electrostatic voltmeter for high voltage, investigation of electrical porcelain and insulators made out of various compositions, investigation of Indian woods in regard to their electrical and mechanical properties, production of stable high-ohmic resistors, development of synthetic insulation from materials available in India and its comparison with similar foreign products.

Preliminary work on the standardization as well as the measurement of potential transformers has been started. This work has priority as there is no other place in south India where such standard measurements can be carried out easily and official certificates issued.

The results of the investigational work of the laboratory generally will be published in the quarterly *Journal of the Indian Institute of Science*, or other local or foreign scientific periodicals.

REFERENCE

1. Production of Standard Waves With a 3,000 Kv Impulse Generator, N. Narayan, K. S. Prabhu. *Journal of the Indian Institute of Science* (Bangalore, India), volume 34, number 4, 1952, pages 113–22.

New High-Voltage Outdoor Load-Interrupter Switch

H. J. LINGAL
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This new completely self-contained switch interrupts line-charging currents, transformer-magnetizing currents, and load currents of transmission voltages. It is composed of a modern vertical-break air switch combined with a porcelain-clad gas-filled chamber. It is small, lightweight, easily operated, and economical.

IN THE OPERATION of electrical utility systems it is often necessary to interrupt transformer-magnetizing currents, line-charging currents, and load currents at locations where a circuit breaker having fault interrupting ability may not be justified. Air break switches are sometimes used for such interruptions; however, at transmission voltages the operations are hazardous since the unconfined electric arcs which result may develop into system faults. To fill the gap between the higher cost power circuit breaker and the air break switch with limited interrupting ability, there has been a need for a dependable and low-cost circuit-interrupting device.

At any station where lines or equipments are to be isolated for inspection and maintenance, safe operating procedure dictates the use of a disconnecting switch having a visible gap separating the isolated portion of the system from the energized portion. It follows that the most desirable form of device for interrupting the current to lines and equipment to be serviced is a load-interrupter switch which combines the functions of circuit interrupter and disconnecting switch. Such a switch can be used to break the load current or charging current without the danger of unconfined arcs, and subsequently provides positive, visible air-gap isolation of the de-energized equipment. The combination of the circuit interrupter and disconnecting switch into one structure conserves space since the over-all device need be little larger than the switch alone, and also makes an economical unit since the same insulators which support the switch may be used to provide the line-to-ground insulation for the interrupter.

The unit described in this article is designed to make available at transmission voltages a dependable and economical outdoor circuit interrupter of the load-interrupter switch type. It consists of a standard outdoor disconnecting switch to which has been added an interrupting device to make possible the interruption of currents up to the continuous rating of the switch. The basic

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Full text of paper 53-46, "A New High-Voltage Outdoor Load Interrupter Switch," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Operations Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1952. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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switch is a modern, vertical-break unit with ice-breaking ability, full continuous and short-time current-carrying capacities, ease of operation, and a minimum maintenance requirement. The interrupter is a parallel-connected unit which carries current only during the interrupting interval so that it can be made light in weight and easy to operate without subtracting from the continuous or momentary capacities of the air switch. It is porcelain-clad, hermetically sealed, and requires no external supply of gas or other auxiliary apparatus for operation.

Practically no material is consumed or lost in each operation so that long life and dependable performance may be expected.

INTERRUPTER SWITCH

THE COMPLETE INTERRUPTER SWITCH for 115-kv service is outlined in Figure 1. The switch is shown closed, and in this position the main switch contacts are closed and a set of separable contacts are closed inside the interrupting unit. The normal current path is through the main switch blade which by-passes the interrupter unit. The center insulator column is rotated to open the switch and interrupter in the following sequence:

1. The first 30 angular degrees of rotation of the driving insulator cause the blade to rotate about its axis to give a contact-wiping and powerful ice-breaking action while releasing the pressure of the stationary contact jaws. Figure 2 shows the beginning of this action.

2. The second 30 degrees of insulator rotation cause the blade to rise from the stationary contact thus diverting the current flow through the interrupter unit and the interrupter isolating blade. Figure 3 shows the main blade rising with the interrupter unit carrying current.

3. After the insulator has been rotated a total of 60 degrees, the main switch blade engages an arm on the interrupter housing which trips an over-center toggle mechanism to cause contacts to part at high speed within the interrupter. Thereby the flow of current is interrupted without any external display.

4. After tripping the interrupter mechanism, further rise of the main blade causes an arm on this blade to engage the interrupter isolating blade. The two blades then rise together during the final 40 degrees of rotation of the driving insulator to establish the full visible air gap required in the disconnecting switch. Figure 4 shows the switch in this fully open position.

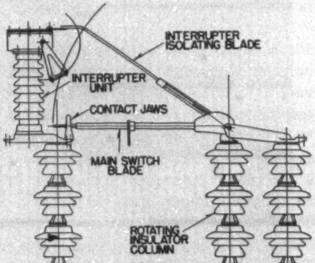

Figure 1. Outdoor load - interrupter switch, single-pole unit

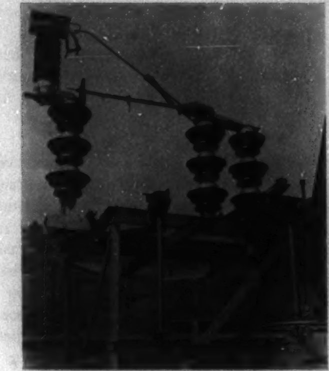

Figure 2. A 115-kv switch unit shown in the closed position

Figure 3. A 115-kv switch unit with the main contacts separated

The closing sequence is the reverse of the opening sequence so that the isolating blade is closed and the interrupter contacts made before the main switch contacts are closed. This prevents prestriking or burning of the main switch contacts while energizing a loaded circuit.

INTERRUPTER UNIT

THE INTERRUPTING DEVICE used in the switch is shown in Figure 5. It consists of a hermetically sealed gas-filled chamber containing an axial-flow interrupting unit. The contacts are actuated by a toggle-type spring mechanism which causes them to open and close at a speed which is substantially independent of the speed of operation of the main switch. This mechanism is located in a housing on the top of the porcelain casing which contains the contacts. A shaft passing through the wall of the housing supports the lever which is engaged by the main switch blade to actuate the mechanism.

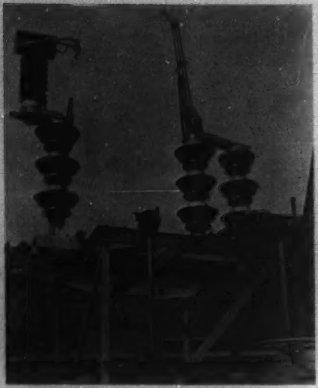

Figure 4. A 115-kv switch unit in the fully open position

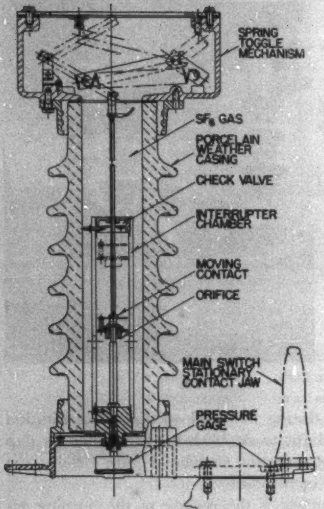
SPRING TOGGLE MECHANISM
SF_6 GAS
PORCELAIN WEATHER CASING
CHECK VALVE
INTERRUPTER CHAMBER
MOVING CONTACT
ORIFICE
MAIN SWITCH STATIONARY CONTACT JAW
PRESSURE GAGE

Figure 5. Cross-sectional view of the interrupting device

The interrupter contacts operate in an atmosphere of sulphur hexafluoride, SF_6, which exhibits excellent arc-extinguishing properties. Extensive experimentation on the use of this gas as an arc-extinguishing medium is described by Lingal, Strom, and Browne.[1] Experiments have shown that only 6 inches of contact separation are required in this medium at atmospheric pressure to interrupt 115-kv circuits. Thus its use makes possible the construction of much smaller and lighter interrupters than previously has been possible. The reduction in size and weight is particularly desirable when interrupters are to be supported on conventional disconnecting switch structures.

Simple separable contacts operating in an SF_6 atmosphere have very substantial current-interrupting ability at high voltages; however, this ability can be increased still further by construction which causes nonionized gas to flow through the arc formed upon contact separation. In this unit the moving contact carries a piston and orifice. The piston operates in an insulating cylinder and compresses gas above it as the contacts separate. The arc is formed in the teflon orifice which also moves upward with the moving contact, and the compressed gas flows down through this orifice to aid in deionization. The addition of this simple means to bring nonionized gas into intimate contact with the arc increases very considerably the interrupting ability of the device.

It will be noted when examining Figure 5 that the entire interrupting structure including the toggle mechanism is filled with the insulating gas. A check valve at the top of the interrupting chamber is open to allow free interchange of gas at all times except during the interval while the contact is moving to the open position.

A pressure gauge at the bottom of the interrupter is located to be visible from the ground and indicates any leakage from the interrupter. The chamber is filled with gas at 30 pounds per square inch (psi) and will operate to interrupt its full rating at 15 psi. The chamber is hermetically sealed and it is not anticipated that any recharging with gas will be necessary during the life of the switch.

TESTS

THE 115-KV DEVICE illustrated in Figures 1 through 5 was tested with 70 kv restored across the contacts of a single pole to simulate interruption of loads on a 115-kv power system. The device successfully interrupted 600 amperes of load current at 50 per cent power factor for

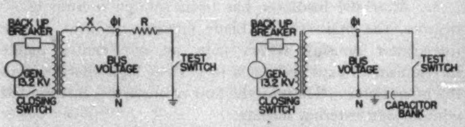
BACK UP BREAKER
X
ΦI
R
GEN. 13.2 KV
BUS VOLTAGE
TEST SWITCH
CLOSING SWITCH
N
BACK UP BREAKER
ΦI
GEN. 13.2 KV
BUS VOLTAGE
TEST SWITCH
CLOSING SWITCH
N
CAPACITOR BANK

Figure 6 (left). Test circuit for load interruption. Figure 7 (right). Test circuit for capacitor-current interruption

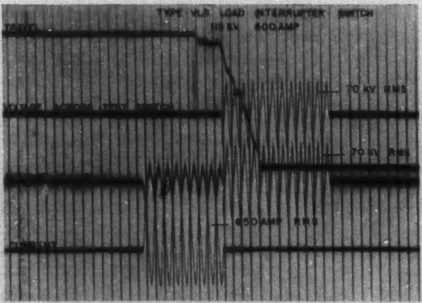

Figure 8. Typical oscillogram of 115-kv switch interrupting load current

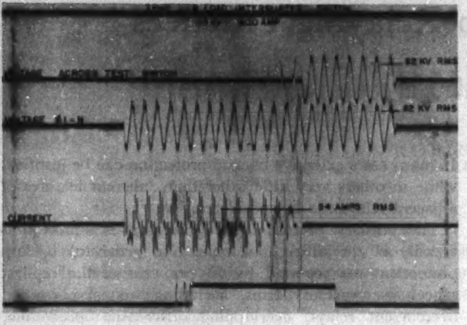

Figure 9. Typical oscillogram of 115-kv switch interrupting capacitor current

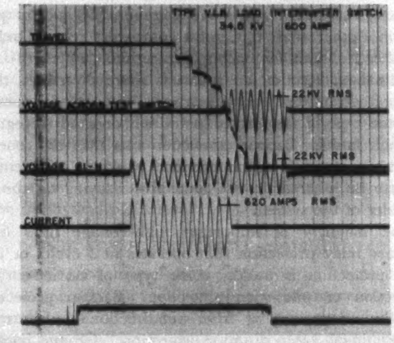

Figure 10. Typical oscillogram of 34.5-kv switch interrupting load current

230 operations. The same unit was used to interrupt 56 amperes of static capacitor current 100 times. The device was in good working order at the conclusion of these tests. The test circuit for the load-current and capacitor-current switching are shown in Figures 6 and 7. A typical oscillogram of a load-switching test where a current of 650 amperes at 50 per cent lagging power factor was interrupted is given in Figure 8. The record of an interruption of 54 amperes of capacitor current is shown in Figure 9.

The unit described here was fitted with stops in the interrupter mechanism to reduce the contact separation to simulate interrupters for lower voltages. The 115-kv unit utilizes a contact separation of $6^1/_2$ inches. It was found that $3^1/_2$ inches was adequate for interruption of 34.5-kv circuits. A unit having the reduced travel was used to interrupt 90 amperes of capacitor current on a 34.5-kv system for a total of 2,020 times. The same unit would interrupt 600 amperes of load current at 50 per cent lagging power factor with no difficulty. A typical load interruption on a 34.5-kv circuit is shown in Figure 10.

All of the tests described have been made with the restored voltage across a single pole equal to the maximum that would be encountered on an effectively grounded system; however, both the 34.5- and 115-kv units have been demonstrated with the maximum voltage which will be encountered on ungrounded systems for load and capacitor currents.

SUMMARY

TO FILL THE NEED for a device to interrupt line-charging currents, transformer-magnetizing currents, and load currents at transmission voltages, an outdoor load-interrupter switch has been developed. This device consists of a modern vertical-break air switch to which a porcelain-clad gas-filled interrupter unit has been added. The use of a gas having good interrupting characteristics and a design which places the interrupter in the circuit only during the interrupting interval makes possible a small, lightweight, and easily operable interrupting device.

The interrupter is completely self-contained and requires no external supply of gas or other auxiliary apparatus for operation. The arc-extinguishing medium is not consumed during operation and the units have long life as demonstrated by a considerable program of testing.

REFERENCE

1. An Investigation of the Arc-Quenching Behavior of Sulphur Hexafluoride, H. J. Lingal, A. P. Strom, T. E. Browne, Jr. AIEE *Transactions*, volume 72, 1953 (*Paper* 53-45); Arc Quenching in Sulphur Hexafluoride (Digest), *Electrical Engineering*, volume 72, April 1953, page 335.

New Oil Circuit Breaker

One of 15 huge oil circuit breakers, which will be the first in the world to have the high interrupting rating of 15,000,000 kva, is being constructed at Philadelphia, Pa., by the General Electric Company's Switchgear Department. Shown being prepared for development tests is one of 3-pole units for the breaker

A Review of Backup Relaying Practices

AIEE COMMITTEE REPORT

THE DATA PRESENTED in this article are the results of surveys conducted by the Relay Project Committee on Transmission-Line Protection. Two questionnaires were submitted to a number of relay engineers representing varied interests throughout the United States and Canada in order to obtain a comprehensive analysis of the extent of backup protection used.

Correct clearing of a fault anywhere on the system requires the proper functioning of several elements including current and potential transformers, protective and auxiliary relays, the battery, the trip circuit including the trip coil, and the circuit breaker. Failure of any of these items in the first line of defense can result in incorrect fault clearing or failure to clear. Backup protection is applied to clear the fault in the event of a first-line protective element failure, and it frequently backs up some and less frequently all of these vulnerable elements. Where all of the first-line elements are backed up, clearing usually is accomplished farther back in the system, involving a greater length of time and disconnecting a greater portion of the system. However, sometimes it is not possible to discriminate at the next sectionalizing point and complete backup protection is difficult.

In its broad sense, backup protection can be described as any protective equipment that can clear a faulted portion of the system in the event that the protective equipment normally intended to clear the fault fails to operate. Thus, the backup protective equipment may be a complete duplication of all elements of the first-line protective equipment connected to protect the same apparatus, or the backup feature may be provided by first-line protective equipment on an adjacent circuit or piece of apparatus. As an example of the latter, a bus having bus differential relays is considered to have backup protection if a fault on the bus is eventually cleared by relays and circuit breakers on transformers and circuits supplying the bus.

Opposed to these complete forms of backup protection are those cases where only a portion of the first-line protective elements are backed up. The most common form of this is the application of a backup set of relays, as in the case of power-line carrier phase comparison relaying where it is common practice to install distance relays and separate ground relays at the line terminals. More frequently, the reasons for installing the backup relays are to provide for taking the first-line relays out of service for maintenance or test and to provide backup protection for adjacent line sections.

Economics is an important factor influencing the choice and extent of backup protection. The cost of providing the protection must be weighed against the value of the power equipment involved, the possibility of a prolonged fault spreading to or causing damage to other equipment, and the effect on the system operation of a prolonged fault. In many cases extensive backup protection can be justified, while in others very little other than inherent features of adjacent relays can be considered.

The primary protection for generators is almost universally of the differential type. No generator backup protection was reported by 30 per cent of the replies; others use various forms, including voltage-restrained overcurrent relays, overlapping differential protection, and distance relays.

Differential protection is also almost universally applied to transformer banks of any size and importance. Transformer overcurrent relays are common for backup protection; other than this, most companies rely on relays at other locations for backup protection.

Primary protection on busses is more diversified than that on generators or transformers, but usually consists of some type of fast protection which does not recognize through faults. Backup protection can take any one of several forms, such as bus overload or partial differential, or may be inherent in the protective relaying on the remainder of the system.

The majority of important high-voltage lines have primary relay protection that operates in 3 cycles or less. This protection is usually some type of carrier-current protection or pilot-wire protection. Backup protection includes relays varying from nondirectional overcurrent to directional 3-step distance protection. Ground backup protection may be directional or nondirectional overcurrent ground relays or product-type ground relays.

Where 3-step distance relays are used as a part of either the primary or backup protection, many different schemes are in use which provide backup protection. On some systems the second and third zones can be set so that the protected line and the line section beyond the adjacent station are covered by the second and third zones. This scheme, where it can be used, provides perfect backup protection since the entire clearing operation is independent of the primary protection which has failed to operate.

The general practice with respect to line backup protection is to depend on the relays at adjacent stations to trip for an uncleared line fault. It is generally recognized that this scheme has limitations and may not operate for all fault locations. The variety of relay schemes used for primary protection influences the backup requirement and makes it difficult to draw general conclusions with respect to line backup protection.

Digest of paper 53-21, "A Review of Backup Relaying Practices," recommended by the AIEE Committee on Relays and approved by the AIEE Technical Operations Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

This paper is a report on a survey of backup relaying practices conducted by the AIEE Relay Committee's Project Committee on Transmission-Line Protection. Members of the Project Committee are J. H. Kinghorn, Chairman, J. E. Barkle, Vice-Chairman, W. E. Marter, L. J. Audlin, B. C. Hicks, W. A. Lewis, A. J. McConnell, M. S. Merritt, C. E. Parks, J. W. Bowman, Frank von Roeschlaub.

Electrostatic Safety for Hospital Operating Rooms

ROBIN BEACH
FELLOW AIEE

After a discussion of the generation of static electricity, the safety factors in hospital operating rooms are examined with emphasis on conductive floors and electrostatic hazard alarms.

ALTHOUGH STATIC electricity generated in hospital operating rooms is of no different parentage than that which haunts industry, there are more causes for electrification within comparatively small areas than in almost any industrial plants. Also, more hazards of potential explosions exist here than in many types of industry.

Due to the administration of pure oxygen, rather than air, with anesthetic products to anesthetized patients through rebreathing systems, explosive ranges are greatly broadened and explosions, when they occur, are intensified in the relatively small operating rooms. When explosions take place, generally at least one life is sacrificed—that of the patient—and, sometimes, several injuries and destruction of physical plant result.

HOW STATIC ELECTRICITY IS GENERATED

STATIC ELECTRICITY is brought into being by the contact of one substance with another. This process by which electrification of the two substances is created at their contacting interface is known as "contact electrification." When in contact, unbalanced interatomic forces across the interface cause electrons to migrate from the substance of higher dielectric constant through the myriad of intervening contacting points to the substance of lower dielectric constant. This phenomenon occurs between all pairs of contacting substances whether they possess conductive or dielectric properties.[1] The substance receiving the electrons thus acquires an electrification of negative polarity while the substance whence the electrons migrate possesses an equal but positive electrification.

The differences of potential across interfacial boundaries which are attained for pairs of contacting substances, in rare instances only, reach a maximum of 1 volt; mostly, the voltage thus developed acquires an order of millivolts and, more commonly, even of microvolts. When two contacting substances which are being separated are conductors, all free electrons on the one surface at the interface return whence they came before the last point of contact is broken.

For insulators, the electrons which are acquired by the one surface in contact with the other are so effectively impounded by their lack of migratory freedom that they are quite effectively entrapped during the process of separation. Hence, if one or both of the substances are excellent insulators, following their separation they each are electrified and each displays the characteristics of respective positive or negative electrification.

Since no substances are perfect insulators, the speed with which the contacting substances become separated comprises a determining factor in how many electrons are entrapped; and, quite generally, the electrification attained from rapid separation of the two substances is materially increased. Within certain limits, the electrification of a substance during separation from another substance increases in linear proportion with the increasing speed of their separation.

The electrified surfaces of two substances in so-called contact comprise a capacitor and these surfaces, on either side of the interface, always possess opposite polarities. As the two electrified surfaces at the interface are separated, assuming the electrification to remain at constant magnitude, the voltage between the surfaces increases directly with the distance of separation. In this manner, potential differences of thousands, tens of thousands, or even hundreds of thousands of volts may be developed between the separating surfaces.

Were it not for the two mitigating factors of charge conduction leakage and ionization loss of charge in the behavior of static electricity as the interfacial surfaces separate in this manner, the voltage across the lengthening gap between the separating surfaces would increase indefinitely. This, of course, it does not do. In industrial operations, both of these discharging processes, together, react to restrain and circumscribe the voltage rise to some degree as the separation of the electrified surfaces increases.

Fire and explosion hazards are the most serious electrostatic problems, and these hazards exist when electric sparks are created in the areas where vapors of flammable products are present. Electrostatic sparks are most commonly initiated by induction where one of the electrified substances approaches a grounded conductor.

By induction, electricity of opposite polarity to that of the nearby electrified substance appears on the grounded conductor. If the voltage between the two exceeds the breakdown potential gradient of the air, a spark occurs. The ignition energy in the spark is a function of both the magnitude of the induced voltage across and the capacitance of the two oppositely electrified electrode areas.

The energies in electrostatic sparks necessary to ignite

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many flammable mixtures are so small that they are designated in tenths to even thousandths of a millijoule. Electrostatic sparks of ignition intensity for flammable vapor-air or vapor-oxygen mixtures may be created by the flip of a sheet on an operating table, by the handling of a rubber tube or rebreathing bag, by sudden spurting of gases through orifices from their cylinders by improper manipulations of valves, by the rubbing of garments on a chair or stool in certain instances, or by walking on improperly constructed or conditioned floors. Igniting sparks in hospital operating rooms may be caused by differences of potential in the order of 1,100 volts.

SAFETY FACTORS IN HOSPITAL OPERATING ROOMS

IN PRINCIPLE, the elimination of electrostatic hazards in operating rooms resolves itself to the provision of suitable conductivity for each and every facility within the operating room, including especially the flooring and the clothing and footgear of the personnel. In regard to flooring, moderately conductive properties are preferred to high conductivity. With conductive qualities provided throughout, no accumulation of static electricity can exist on facilities within hospital operating rooms; and, hence, no electric sparks can occur to ignite ambient flammable mixtures. In practice, such provisions of conductivity within operating rooms, while recognized as essential in implementing the inexorable tenets of safety and thus in eliminating all electrostatic hazards, seem not to be regarded as gravely as the jeopardy of the situation requires.

The safety provision that operating room personnel unfailingly change into cotton garments throughout and use conductive footgear before entering the hazardous areas of operating rooms should constitute an inviolate regulation of every hospital and one that should be demanded of each and every member of the operating staff.

Although conductive rubber coverings on mattresses and conductive rubber sheets and pads for operating tables are available and extensively used, these and other associated facilities, such as sheets, pillowcases, and blankets, when dry, may generate dangerous potentials when they are flipped on or off operating tables in the many ways practiced by nurses and doctors. Sheeting and other cotton goods used on operating tables should be rendered reasonably conductive by some acceptable means. Unless these problems are resolved, operating tables will continue to remain a focal center of incipient hazards.

The rubber tubing, rebreathing bags, and other such specialized appurtenances used in the rebreathing techniques of applying anesthesia are still largely dielectric and, as such, they constitute particularly susceptible instrumentalities for the generation of dangerous electrostatic potentials. Rubber facilities seem not to be sufficiently developed as yet to meet satisfactorily the exacting requirements of anesthesiologists in providing superior anesthetizing service and enduring conductivity. Also, the rubber gloves used by surgeons in operating rooms, until made conductive, will doubtless continue as incipient sources of electrification.

The practice by surgeons of dusting into their rubber gloves talc powder and other dispersions which are highly dielectric should not be permitted in operating rooms. Films of talc, accumulating on the floor, develop sufficiently high resistance to render semiconductive flooring almost nonconductive and, therefore, hazardous.

Most of the facilities in operating rooms, other than the operating table, are portable and are provided with casters or rubber leg tips. The casters and leg tips, of course, are composed quite generally of conductive rubber with the thought that their contact resistance to floor is low. However, talc has been found to increase their contact resistance to dangerously high values. Suitably rounded, brass tips on the legs of stools, tables, and other such portables provide minimum contact resistances to floor, are safe from mechanical sparks, and slide easily on floors.

Drag chains, attached to portable equipment for the alleged purpose of providing additional grounding contact with flooring, have been shown by repeated tests to possess little, if any, value as a means of grounding. The separation of the dangling links constitute an ignition-spark hazard from electrostatic discharge; and, in the interest of safety, the use of such chains should be abandoned. A positive and effective grounding device, now being developed, soon will be on the market to replace drag chains in hospitals.

CONDUCTIVE FLOORS IN OPERATING ROOMS

THE SCIENTIFIC PHILOSOPHY which is basic to the recommended use of conductive safety floors in hospital operating rooms stresses the provision of conductive intercoupling between all operating room equipment and personnel for the elimination of any differences of electrostatic potential. Proper intercoupling by appropriate and well-maintained conductive flooring is the priceless key to effective control of almost all of the electrostatic hazards currently existing in hospital operating rooms. The National Fire Protection Association (NFPA) Committee on Hospital Operating Rooms is to be complimented on its propitious recognition and adoption of conductive flooring for the resistance-controlled ground plane to serve as the intercoupling agency between all floor-borne equipment and personnel. To translate into safe practice this basic concept of NFPA, however, certain factors relating to it require close analytical scrutiny and sound engineering judgement, born of specialized experience and research.

SAFE RESISTANCE LIMITS FOR FLOORS

THE UPPER AND LOWER SAFE RESISTANCE LIMITS for hospital operating room floors are somewhat critical. The most effective control of the fire and explosion hazards in these hazardous areas is contingent not only on the floors possessing resistance between the rather narrow upper and lower safe limits but, also, on maintaining the cleanliness of the floors to preserve the desired resistance.

The lower the floor resistance is made, the more effectively electrostatic potentials and their spark hazards would appear to be controlled, actually to their complete elimination. However, low-resistance flooring, while appearing to possess most desirable properties in this respect, fortunately is not necessary, electrostatic-wise; and, unfortunately, low-resistance flooring introduces its own peculiar brand of serious hazards.

If the live or "hot" wire of an electric cord or electric appliance becomes exposed accidentally and makes contact with conductive flooring, and thus with its intercoupled equipment and personnel, the surgeons and attendants in being electrified could receive electric shocks, possibly with grave consequences to themselves or the patient, by touching any grounded object.

Although the threshold alternating current for lethal electric shock lies in the order of 100 milliamperes, mild electric shocks, which may cause flinching from sudden muscular responses especially of the fingers, occur at current values as low as 1 milliampere. Therefore, prudent judgment relating to safety considerations prescribes the limitation of threshold shock current, by resistance control, to below 1 milliampere. For 125-volt service, the threshold control resistance is thus indicated in the value of 125,000 ohms between any part of the floor and ground or through the floor between spaced electrodes.

In addition to electric shock hazards to operating room personnel, an exposed live wire may cause electric arcs of sufficient heat energy, under conditions of low-resistance flooring, to ignite ambient flammable mixtures. The elimination of this potential ignition by resistance control, incorporated homogeneously into the flooring, is predicated on the three following basic factors:

1. Threshold ignition energy of 0.001 millijoule for flammable mixtures of anesthesia vapors with oxygen.
2. Threshold electric shock and arcing currents of about 1 milliampere.
3. Threshold time factor in the order of 0.01 millisecond for striking an electric arc.

Based on these three fundamental factors, the limiting resistance in the arc circuit to attain the threshold ignition energy indicates a value in the order of 100,000 ohms.

Hence, to guard against electric shock hazards to operating room personnel and to eliminate the ignition hazards of electric arcs, both of which hazards originate from exposed live wires of 125-volt electrical service, the threshold safety resistance between floor and ground or through the floor between spaced electrodes is about 125,000 ohms.

Applying a reasonable factor of safety to the threshold of safety resistance of flooring or of flooring to ground, the lower safe limit of this resistance, in the opinion of the author, is 250,000 ohms rather than the value of 25,000 ohms recommended in NFPA Bulletin number *56*.

The safe upper limit of floor resistance is established by the time required for the discharge through floor of the highest source of static electricity in the operating room. If this discharge time is less than the time required to accumulate the generated static electricity, the electric charge is then dissipated as rapidly as it is generated and no appreciable differences of potential can occur.

In this regard, the research studies of Paul Guest and his associates at the United States Bureau of Mines on the charging and discharging rates for large capacitors,[2] such as insulated hospital operating tables, lead to the conclusion:

Provision for removing aggregate charges in 0.01 second, or 15 to 30 times faster than they normally can be developed in anesthetizing locations, would seem to give enough margin of safety.

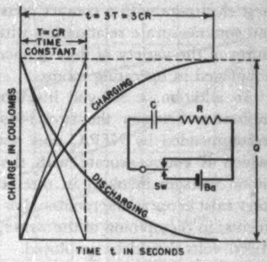

Figure 1. The time constant T for the electric circuit shown depends on the values of C and R. Its value is identical for charging and discharging

These studies also disclosed that hospital operating floors with a resistance to ground of 50 megohms are safe from electrostatic spark hazards for the largest capacitors found in hospital operating rooms under maximum charging rates known to occur there. The significance of the time constant in controlling the charging or discharging rate of a capacitor through a resistor, as shown by the electric circuit insert, is explained in Figure 1.

Thus applying a reasonable safety factor to a floor resistance of 50 megohms, which is already determined to be safe, the upper safe resistance limit for hospital operating room floors to ground or between 3-foot spaced electrodes is indicated in the order of 10 megohms rather than the 1-megohm value stated in NFPA Bulletin number *56*.

No equipment measured to ground should exceed the upper safe resistance limit of 10 megohms. The contact resistances of floor-borne equipment should be less than the lower limit of floor resistance for maximum safety.

After the floors of operating rooms have been provided with ground and surface resistances within the upper and lower safe limits, as explained and recommended here, they can be rendered electrostatically dangerous, nevertheless, by the subsequent and ill-advised use of insulating coatings of polishing wax or by inadvertent accumulations of talc and other forms of insulating dispersions. However, floor dressings which maintain the floor resistance within the prescribed limits may be safely used, if desired.

MEASURING THE RESISTANCE OF FLOORS

THE 5-POUND TEST ELECTRODES, recommended by NFPA for measuring the resistance of floors, apply a pressure of 1 pound per square inch (psi) on the floor surface. NFPA also recommends that between the two 3-foot spaced electrodes, a resistance-measuring instrument should be employed which applies a 500-volt difference of potential between them. These specifications seem ill-advised both as to the contact pressure of electrodes on the floor and as to the voltage applied for measuring floor resistance under conditions which exist in operating rooms.

Almost any equipment supported on the floors of operating rooms, including even stools and lightweight tables, because of their small contact areas with the floor, yield high contact pressures which range from over 100 psi for stools to as high as 1,000 psi for operating tables. Hence, test electrodes with a contact pressure of only 1 psi possess no commensurate relationship with the high contact pressures of the variety of floor-supported equipment, such as employed in operating rooms.

In addition, a 500-volt instrument for measuring floor resistance between the two 3-foot spaced electrodes, as recommended by NFPA, does not impress a test voltage which is commensurate with the magnitude of electrostatic voltages involved in threshold sparking hazards as they exist in operating rooms. For such resistance measurements, in the opinion of the writer, an instrument rated at 1,000 volts should be employed.

This opinion is predicated on the well-known practice in the technique of measurements of utilizing measuring parameters which simulate as closely as possible those which exist in the field. Hence, since an electrostatic potential of about 1,100 volts has been determined as the threshold value for creating ignition sparks in hospital operating rooms, then a resistance measuring instrument provided with a 1,000-volt potential source should be employed in measuring floor resistance. This is especially true where high contact resistances exist between the electrodes and the floor.

Resistance values differing widely in magnitude have been obtained by the author in measuring the resistance of floors in hospital operating rooms by using 500- and 1,000-volt instruments. Each of the two instruments was successively connected to the same pair of test electrodes which were not moved during the comparison tests.

With the application of a power supply of 1,000 volts in the resistance-measuring instrument, as recommended by the author, the contact resistance between each electrode and floor surface may become decimated by virtue of localized ionization phenomena. These ionization phenomena occur in a like manner from electrostatic voltages of identical magnitude when impressed between any floor-bearing facilities and the floor.

Resistance-measuring instruments are provided with internal resistances which, in some instances, vary between wide limits. Unless the value of the internal resistance is known, a 500- or 1,000-volt instrument, used in measuring a floor resistance whose value is commensurate with the internal resistance of the instrument, actually may apply across the floor resistance being measured only a small part of its rated voltage. For example, one such 500-volt instrument possesses an internal resistance of 500,000 ohms; and, if the floor resistance being measured is about 500,000 ohms, the voltage applied to the test electrodes on the floor is only 250 volts rather than the rated 500 volts. On the other hand, if the floor resistance is 5 megohms, this same 500-volt instrument impresses a voltage across the two test electrodes of 454 volts, a value reasonably close to the 500-volt rating. However, if the floor resistance is 100,000 ohms, this 500-volt instrument only impresses about 83 volts across the test electrodes on the floor—a voltage departing greatly from the 500-volt rating.

Several of the 500- and 1,000-volt resistance-measuring instruments in common use possess internal resistances within the range of 80,000 to 100,000 ohms. However, some ohmmeters have internal resistances of several megohms. The term ohmmeter, where the expression occurs in this article, is used in the generic sense rather than referring to any specific make of instrument. Floor resistances measured by these various instruments may vary widely by virtue of the differences in the relative voltages impressed across the test electrodes. Hence, the NFPA could well clarify this confusion by specifying, for its recommended upper and lower safe limits of floor resistance, the tolerance range of impressed voltages which are suitable in measuring floor resistances.

The resistance between two test electrodes on a floor may reside largely in the contact resistances. When the measurement of the actual floor resistance is to be made in order to determine whether floors were initially constructed within the specified safe resistance limits, the test electrodes may then, and only then, be placed on spots of the floor which have been thoroughly cleaned by sandpapering. However, for all other measurements of floor resistance for the purpose of investigating whether the resistance of operating room floors, as normally maintained for day-to-day service, meet the specified safe resistance limits, the test electrodes should be placed about the floor area without cleaning the spots for the electrodes.

No water should be applied to the floor just prior to the resistance measurements. Tests should be conducted only several hours after the floors have been washed, such as the morning after the floor washing of the previous day.

In order to provide a floor-bearing pressure for test electrodes more nearly commensurate with the values of floor-borne equipment in operating rooms, the author has investigated 5-pound electrodes equipped with three brass supporting legs. If the contact dimensions of each leg tip with the floor are 1/8 by 1/8 inch, the pressure exerted on the floor by each leg tip is about 107 psi, a value more closely in keeping with those of the equipment utilized in operating rooms. The leg tips for these electrodes are used either bare or, preferably, with conductive paste applications—thus to reduce still further contact resistance. At this writing the author is not prepared to recommend the use of this measuring technique, but rather proposes that further study well might be devoted to exploring its applicability.

Apropos of the suggested 3-leg 5-pound electrodes, as mentioned previously, large-scale multilegged electrodes were simulated in measuring floor resistance by using two conventional 16-pound metal stools resting on conductive linoleum flooring with two legs of one stool facing two legs of the other stool with a spacing of 3 feet between them. When the legs of each stool were provided with conductive rubber tips, the floor resistance between the two stools averaged 6.5 megohms. When the rubber tips on the legs were removed, the floor resistance between the two stools average 112,500 ohms. Later it is disclosed that the actual resistance of this floor was about 5,000 ohms. This revealing fact, therefore, gives definite proof that practically all of the 6.5 megohms is contact resistance.

These measurements are of significant importance in disclosing the dangerously high contact resistance provided by conductive rubber leg tips and casters on portable stools, tables, and other such equipment in hospital operat-

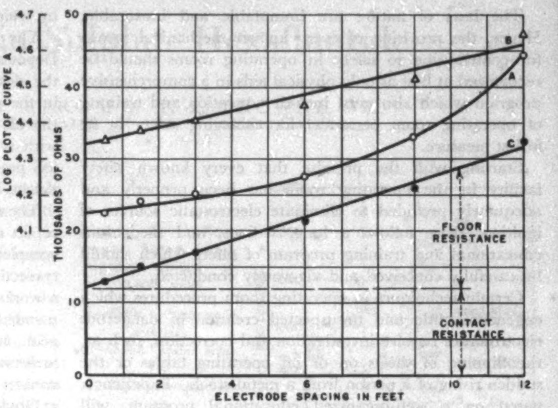

Figure 2. Curve A depicts the composite resistance characteristic of conductive linoleum flooring and of the electrode contacts, as measured by NFPA standard electrodes and a 500-volt d-c ohmmeter. The linear log plot from the data of curve A, as shown by curve B, indicates the resistance characteristic to be a logarithmic function. Curve C represents the resistance characteristic of the same floor, using the method of measurement described here, showing reduced and constant contact resistance and linear floor resistance

ing rooms. This vast difference of resistance displays the vagaries in resistance measurements caused both by contact phenomena and by floor-bearing pressure effects.

Since the subject of measuring the resistance of flooring in operating rooms is so important safety-wise, as well as in determining whether contractors have met standards of construction and terms of specifications in laying operating room floors, a program of research work is indicated for developing ways and means of providing really precise measurements of floor resistance itself, rather than of contact resistances between the test electrodes and floor.

The author has devoted considerable study and test procedure to investigating resistance measurements on conductive linoleum in hospital operating rooms. Some of the data relating to such resistance measurements on conductive linoleum between NFPA standard electrodes spaced from 6 inches to 12 feet apart are shown by the irregular curve *A*, Figure 2. The conversion of this resistance curve to logarithmic ordinates is depicted by the straight line *B*, in the upper part of the chart.

With effective conductive paste applied to the bare metal faces of the NFPA test electrodes in their contact with the floor, the contact resistance when using the same ohmmeter is about halved. The improved resistance characteristic for the measurement of the same floor resistance is shown by the lower curve *C*, Figure 2, for which the actual floor resistance is seen to be markedly reduced, homogeneous, and linear.

Thus, when the floor resistance of this conductive linoleum was measured in the manner suggested here, it is seen to be low and to possess a linear characteristic. On the other hand, when the floor resistance was measured by the standard NFPA method, the contact resistance between each electrode and floor is observed to be high and a logarithmic function rather than linear.

For this reason, in taking measurements by the NFPA method, the type of electrodes and their floor-bearing surface and pressure, the voltage applied to the electrodes by the ohmmeter, and the internal resistance of the ohmmeter, are all significant factors in influencing the results.

In measuring floor resistance for any of the many purposes for which such data are used, it is suggested that tests be taken for several distances and the data plotted as shown in Figure 2. By so doing, important information is disclosed regarding the resistance characteristics of the floor and the electrode contacts and, also, regarding the manner and care utilized in conducting the tests. Some such measuring technique, as herein used and explained, is suggested for the consideration of NFPA.

HOMOGENEOUS RESISTANCE FOR FLOORS

THE HOMOGENEITY OF FLOORING in hospital operating rooms is basically important in preserving everywhere on the floor-plane resistance values which lie within the recommended upper and lower safe limits. With moderately conductive floor coverings, continuity and homogeneity of the flooring are inherently provided.

The NFPA disapproves of the use in operating rooms of any flooring composed of discrete sections, with their inevitable cracks for spawning infection, such as squares of rubber, asphalt, linoleum, cork, or other compositions regardless of conductivity. Neither does it approve granolithic floors for the same reason, such as terrazzo, tile, and mosaic structures. In such floors, the conductive cements wear away rapidly and leave high-resistance flooring on which floor-borne equipment rests.

ELECTROSTATIC HAZARD ALARMS FOR INSTRUCTION

AFTER OPERATING ROOMS have been provided with satisfactory conductive flooring and with floor-borne facilities equipped with rounded brass leg tips and an effective grounding device to replace drag chains, thus yielding minimum contact resistance with floors, as well as personnel utilizing prescribed safety measures of conductive clothing and footgear, the undertaking of rendering the operating room safe from electrostatic hazards has encompassed only the physical phases of the safety conversion. At this stage enters the human element with varied emotions, errors of omission and commission, as well as lack of adequate training in electrostatic hazards.

The laws of nature are immutable and inexorable. Hence, the provision of every known mechanical means for contributing to safety in operating rooms should be recognized at best as only physical aids in a comprehensive program which also must include education and training of operating room personnel for achieving safety in its fullest measure.

Starting with the premise that every known safety facility in the operating room has been properly and adequately provided to eliminate electrostatic sources of ignition, there follows a long, tedious, and meticulous educational and training program of safety which should be carefully conceived and vigorously conducted.

Certain techniques in operating room procedures which engender subtle and unsuspected creation of dangerous electrostatics require investigation and correction, such as, the flipping of sheets on or off operating tables or the sudden rising of a person from a metal stool. Experience, based on a well-organized educational program, will prescribe that, in order to eliminate these and other electrostatic hazards, such normally rapid actions as mentioned should be resolved to slow motion for permitting time dissipation of electric charge.

The instrumentality around which such an instructional program for operating room personnel would be formulated comprises an electric-field detecting instrument which, by being connected to an overhead antenna system in the operating room, detects electrostatic potentials in excess of a preset safety threshold at which spark and ignition hazards arise.

Since the threshold potential for creating sparks in operating rooms has been determined at about 1,100 volts, this electric-field detector should be adjusted to operate its alarm at a slightly less value, about 1,000 volts. If adjusted for too low a voltage, the alarm would sound unnecessarily. When this preset potential of 1,000 volts is exceeded by any one of many possible ill-advised acts of operating room personnel, the presence of such hazards is made known by a low buzz of the indicating instrument and by the lighting of a red signal lamp. In this manner, the operating room personnel are alerted to the fact that some of their manipulations or movements are causing hazards. Then each cause should be investigated, isolated, and studied with training instituted to eliminate its repetition.

To illustrate, a person wearing rubber-soled shoes would find that the electrification at each step in the process of walking would, under favoring electrostatic conditions, sound the buzzer each time his shoe tips were successively raised from the floor. Even high-resistance leather shoes commonly give rise to similar electrostatic impulses. Maximum safety, in this respect, prescribes the use of conductive footgear.

In the interest of acquiring safe techniques in various manipulations and movements within operating rooms, the anesthesiologist could isolate those situations which, by energizing the hazard detector, manifest certain dangers from electrostatic sources. Thereafter, he could demonstrate to the operating room personnel, as a training aid, slow-motion procedures and other improved techniques by which hazards from electrostatic sources are resolved.

The Bureau of the United States Naval Ammunition Depot at Crane, Ind., prepared a brochure[3] which explains the death-dealing hazards of electrification at this plant in the processing, handling, and bagging of gun powder; the use of an electric-field detector, called the Staticator, with systems of overhead antenna for discovering unsafe job practices; and the instructional methods instituted to detect, isolate, and correct such electrostatic hazards.

The reading and study of this invaluable and interesting report of how a Staticator may be employed to resolve to complete safety electrostatic hazards, by detecting and correcting the causes of electrification and by installing a workable system of instruction for the personnel, is commended to each nurse, anesthetist, anesthesiologist, surgeon, and hospital administrator who is entrusted with the preservation of life and property during the specialized services performed in hospital operating rooms.

Obviously time, study, and perseverance are required to adapt each member of the operating room staff to his individual responsibilities in detecting and correcting, by a training program, the potentially hazardous conditions.

As a means of resolving theory into practice, an electrostatic-field annunciator system was recently installed for trial in one of the major hospitals in the New York City Department of Hospitals. The objectives of this experimental provision embraced both salient phases of the educational advantages offered by this system. These advantages are

1. The detection and signaling of dangerous potentials as caused by inadvertent acts of operating room personnel.
2. The subsequent isolation of the electrostatic causes which operated the alarm signals with the purpose of resolving the apparent hazards and of providing group instruction, as a "dress rehearsal," to preclude repetition of the hazards.

Now, after a trial of about 3 months with the electric-field-annunciator system, the operating room personnel in this experimental area is convinced of the advantages in having such a hazard annunciator; and the personnel has shown interest and enthusiasm in detecting and isolating the sources of dangerous electrostatic potentials, as well as entering co-operatively into a program of instruction to eliminate recurrences of such electrostatic hazards.

Recommendations now are being considered to equip each operating room of this suite with an individual antenna and control panel. A composite control panel to indicate alarms and signals from each of the antennas is included in the plan of installation to be so located that it comes under the observation of the supervisor in charge of the operating suite. This apparently will be the first such complete Staticator installation in any hospital within the metropolitan New York area.

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Arc Quenching in Sulphur Hexafluoride

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SULPHUR HEXAFLUORIDE (SF_6) is extremely stable and inert, remains a gas down to −62 degrees centigrade at normal pressure, and is comparable to oil in dielectric strength at only 30 pounds per square inch gauge pressure. Its dielectric strength is generally two or three times that of air although the ratio is affected by the electrode configuration, voltage wave shape, and pressure.

Whereas gaseous halogen compounds, particularly SF_6, have been shown during recent years to possess excellent insulating properties, practically no significant studies have been reported in regard to their arc-quenching or circuit-interrupting abilities.

An investigation has been made which shows that SF_6 can interrupt currents in the order of 100 times those that can be interrupted in air in the same interrupter. This is in marked contrast to the relatively modest superiority of this gas over air as an insulating medium.

A theoretical deterrent to the use of SF_6 for arc quenching is the corrosive nature of the arc-produced decomposition products, but experience has shown that this is a tolerable difficulty which can be minimized by using absorbing agents, and by the choice of materials and design of the interrupter.

Some results of an experimental study of a-c circuit interruption at voltages up to and including 13,800 by a 3-inch plain-break arc in a simple enclosure filled with this gas at various pressures up to 175 pounds per square inch are shown in Figure 1. Comparative results at 1,150 volts in air are shown by the dotted line near the zero-current axis. Whereas at atmospheric pressure, the currents which could be interrupted in SF_6 were somewhat less than 100 times those which could be interrupted in air, the comparison was more favorable to SF_6 at the higher values of voltage and pressure. Particularly striking is the comparatively small dependence of the limiting current upon circuit voltage at the higher values of gas pressure.

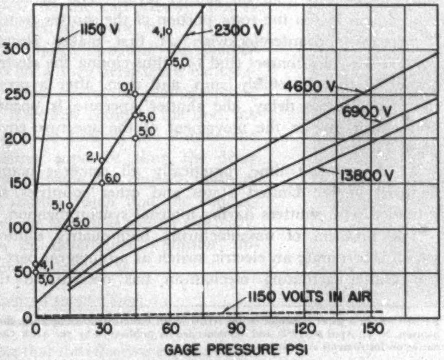

Figure 1. Interruption performance at zero power factor of 3-inch plain-break gap in SF_6. Numbers by points are "works" then "fails"

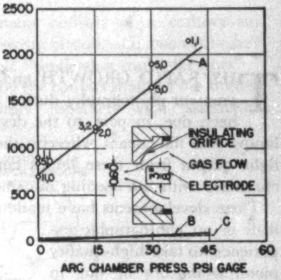

Figure 2. Zero power factor interrupting ability at 13,800 volts

A—Puffer interrupter with SF_6
B—3-inch plain break gap
C—Puffer interrupter with air

In general, the interrupting ability of a plain-break arc in SF_6 was found to vary roughly with the arc length times the absolute pressure and to be sensitive in an inverse way to the rate of rise of restored voltage as determined by the circuit.

Admixture of considerable proportions of air with the SF_6 reduced the interrupting ability drastically but the performance was not too sensitive to small amounts of air.

The interrupting performance of an arc in SF_6 can be greatly improved by even moderate gas flow. This is illustrated by curve *A* of Figure 2 obtained with a simple "puffer" mechanism in which flow was produced by a piston containing the sketched orifice and attached to the moving electrode. The improvement obtained is shown by comparison with curve *B* for a 3-inch plain break in SF_6. Performance of the puffer device when filled with air is shown by curve *C* (dotted).

The remarkable arc-quenching ability of SF_6 is not yet fully understood, but it is believed to be connected with the electron-trapping tendency of this "electronegative" gas. Study of the arc-quenching action is being continued. Practical application for circuit interrupting is being made in the simple gas-filled load-break interrupters for high-voltage service described in a separate article.[1]

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Electronic Instruments for Production Testing of Camera Shutters

R. W. LAVENDER

The test instruments used for checking time synchronization between the shutter switch contact "make" and the opening of the shutter aperture, the equivalent energy transfer of the "momentary make" type of shutter switches, and an instrument for checking the life of shutters during production are briefly described.

THE RAPID GROWTH and widespread interest in amateur photography during the last 2 decades have been due, in part, to the development of photoflash lamps and the means whereby the peak intensity of the light output from these lamps could be accurately synchronized with the opening of camera shutters.

These developments have made it possible for one with little or no photographic experience to take high-quality pictures indoors or out in almost any kind of weather.

The early hazardous method of open flash photography, namely, that of igniting magnesium powder, was superseded in late 1930 with the introduction of the first photoflash lamp. This lamp contained, in an atmosphere of oxygen, aluminum foil which could be ignited by the heat produced when an electric current was passed through a wire coated with a chemical primer. The inherent time delay, of approximately 20 milliseconds between the closing of the electric switch, which caused current to flow through the flash lamp filament, and the peak intensity of the light emitted from the lamp required the development of synchronizers or flash guns which would time-delay the operation of the camera shutter sufficiently to allow the light output from the lamp to be at its peak intensity when the camera shutter was in its maximum open position.

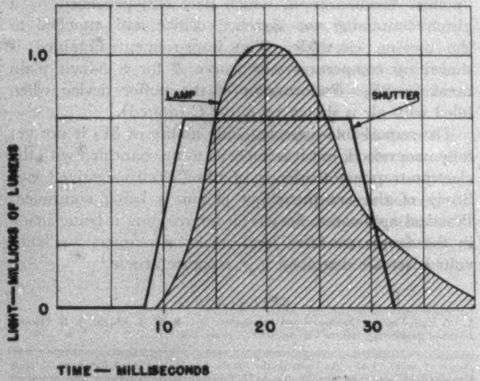

Figure 1. The optimum time relationship between the opening of a camera shutter and the light output from a photoflash lamp. Theoretical shutter speed 1/50 (20 milliseconds) and theoretical flash lamp time also 20 milliseconds

Figure 1 illustrates the optimum time relationship between the opening of a camera shutter and the lumen output from one type of photoflash lamp. Time is measured from the closing of the electric switch. Note that the shutter is wide open during the time when the light output from the lamp is at its maximum value.

Various external shutter-flash synchronizing devices were developed between 1930 and 1940. The shutter delay mechanism used in these devices was, in general, either mechanical or electromechanical and was usually supplied as part of the photoflash lamp holder assembly.

In 1939, the first box camera having an internally synchronized, "between-the-lens type" of shutter was introduced. This type of shutter, presently used by one manufacturer in its box cameras, is shown in Figure 2.

Operation. Depressing the shutter lever (*1*) causes the shutter actuating arm (*2*) to move clockwise, thereby storing energy in the spring (*3*). When the shutter lever is fully depressed, the shutter actuating arm is automatically disengaged from the shutter lever. The actuating arm, which is also the rotor portion of the shutter switch, then travels counterclockwise. It first makes electric contact with the contact stud (*4*), thus closing the electric circuit to the photoflash lamp, and then, after a preset mechanical time delay, the shutter aperture is opened and closed due to the movement of the aperture cover plate (*5*).

At the present time, practically all cameras manufactured in the United States and other countries are provided with shutters having internal synchronization.

The problem of manufacturing high-quality shutters which incorporate an electric switch as an integral part of the shutter actuating mechanism has necessitated the

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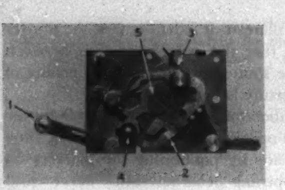

Figure 2. A type of box camera shutter with mechanism for synchronizing flash lamp

development of rapid and dependable methods for obtaining precise data on the time relationship between the initial contact, or "make," of the electric switch in the shutter and the opening of the camera shutter aperture.

A relatively large number of methods have been developed and used during the past 20 years for determining shutter efficiency and shutter-flash synchronization. Notable among these, and of more recent development, is a method, Figure 3*a*, whereby the opening of the shutter aperture is represented by a trace on a cathode-ray viewing screen.

The operation is as follows: Depressing the shutter lever closes the shutter, which, in turn, triggers a single-sweep circuit in the cathode-ray oscilloscope. As the shutter aperture opens, the collimated light transmitted through the shutter is picked up by a phototube. The output voltage from the phototube amplifier is connected to the vertical deflection plates of the cathode-ray tube. On the intensity or *Z* axis of this tube, timing markers are impressed. These are generally either 1 or 10 milliseconds apart.

A trace of the shutter aperture opening characteristic as it might appear on the cathode-ray tube is illustrated in Figure 3*b*.

By rapidly counting the marker dots on a long-persistence cathode-ray tube screen, or photographing the trace and counting the dots, the total open time of the shutter, the effective exposure time, the delay time between the contact make of the shutter switch and the shutter-opening, as well as shutter efficiency, can be determined. Shutter efficiency is defined as:

$$\frac{\text{Effective Exposure Time}}{\text{Total Open Time}}$$

Note that the effective exposure time is the total time during which the shutter aperture is one-half or more than one-half open.

It is apparent that 100-per-cent inspection of camera shutters on a production line would not be practical using the cathode-ray tube method just described.

OSCILLOGRAPH SHUTTER-FLASH SYNCHRONIZER

A SHUTTER-FLASH SYNCHRONIZER, Figure 4, suitable for both production and laboratory use, was developed several years ago.

Essentially, the instrument consists of a cathode-ray oscilloscope with a single-sweep circuit, and two calibrated and independently variable "single-shot multivibrators"—all of which are triggered by the contact make of the shutter switch. The multivibrators together with associated

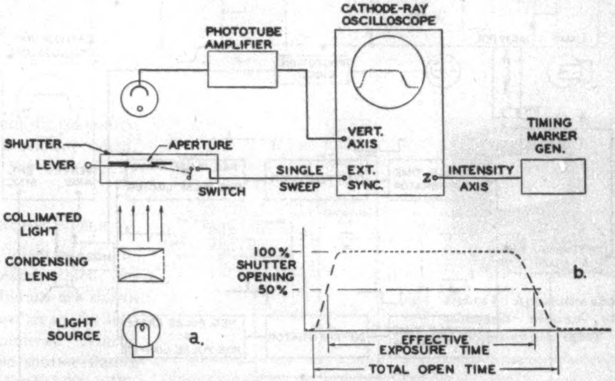
CATHODE-RAY OSCILLOSCOPE
PHOTOTUBE AMPLIFIER
VERT. AXIS
TIMING MARKER GEN.
SHUTTER
LEVER
APERTURE
SWITCH
SINGLE SWEEP
EXT. SYNC.
Z
INTENSITY AXIS
COLLIMATED LIGHT
CONDENSING LENS
LIGHT SOURCE
a.
100%
SHUTTER OPENING
50%
b.
EFFECTIVE EXPOSURE TIME
TOTAL OPEN TIME

Figure 3. A block diagram showing the arrangement of the shutter, the light flowing through it onto a photoelectric cell, and how the circuit is connected to a cathode-ray oscilloscope on which the shutter aperture characteristic appears. The characteristic is explained in Figure 3b

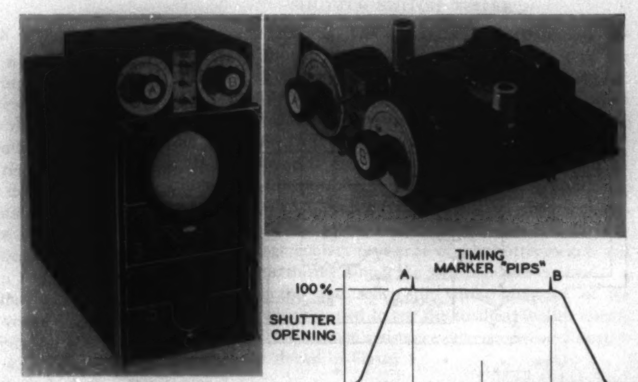
A
B
TIMING MARKER "PIPS"
100%
SHUTTER OPENING
0
10
20
30
40
TIME (MILLISECONDS)

Figure 4. Apparatus for generating marker pips A and B shown above right and on the left shown installed on an oscilloscope. A shutter characteristic appears below with markers indicated

pulse-shaping networks provide time-delayed marker "pips" which are superimposed on the shutter aperture opening oscillograph trace. Such a trace as might be viewed by a production-line inspector of camera shutters is illustrated in Figure 4, lower right.

The timing markers are normally set equidistant in time from the 20-millisecond ordinate which corresponds to the time at which one type of photoflash lamp would be at its peak lumen output. Time, as before, is measured from the initial passage of current through the photoflash lamp filament. The time, or position separation, of the markers in normal production testing is generally fixed and depends on the shutter being tested. If, in the case shown, both markers are on top of and uniformly spaced relative to the shutter aperture plateau, it indicates that the shutter efficiency is high and that the synchronization between the contact make of the shutter switch and the opening of the camera shutter aperture is correct.

When used in the laboratory, a rapid check of shutter efficiency and aperture opening and aperture closing time can be conveniently made by positioning the markers on the shutter-aperture-opening characteristic curve and obtaining the time difference between them by subtracting the delay time, as indicated on the calibrated dials, of marker *A* from that of marker *B*.

The timing-marker generator chassis comprising time-calibrated dials, range and marker selector switches, multivibrators, clippers, and so forth, is located on the top of the standard cathode-ray oscillograph. It is shown with its cover removed in Figure 4, upper right.

A block diagram of the marker generator and mixer circuit is shown in Figure 5.

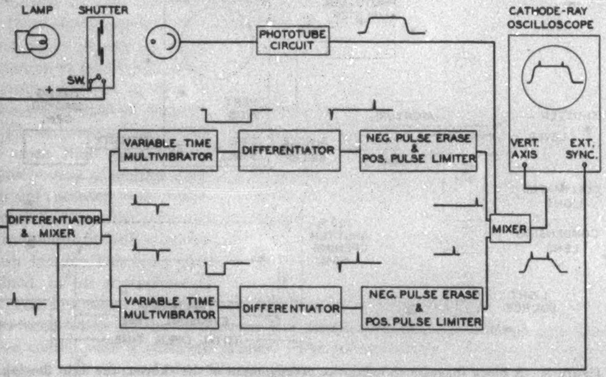
LAMP
SHUTTER
SW.
+
PHOTOTUBE CIRCUIT
CATHODE-RAY OSCILLOSCOPE
VERT. AXIS
EXT. SYNC.
VARIABLE TIME MULTIVIBRATOR
DIFFERENTIATOR
NEG. PULSE ERASE & POS. PULSE LIMITER
DIFFERENTIATOR & MIXER
MIXER
VARIABLE TIME MULTIVIBRATOR
DIFFERENTIATOR
NEG. PULSE ERASE & POS. PULSE LIMITER

Figure 5. Block diagram of a shutter-flash synchronizer showing how the marker pips are inserted in the characteristic on the oscilloscope

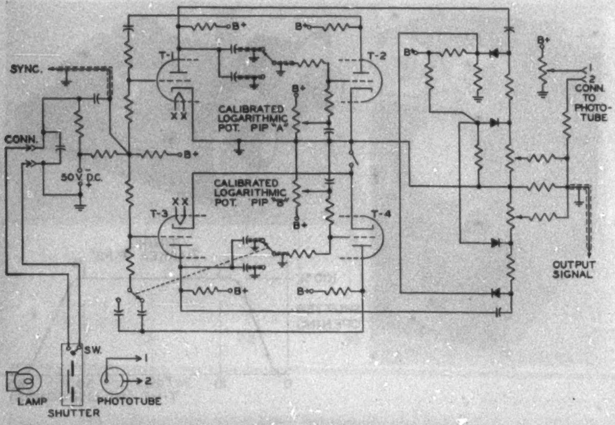
SYNC.
CONN.
50 V D.C.
T-1
T-2
T-3
T-4
B+
XX
CALIBRATED LOGARITHMIC POT. PIP "A"
CALIBRATED LOGARITHMIC POT. PIP "B"
1
2
CONN. TO PHOTO-TUBE
OUTPUT SIGNAL
SW.
LAMP
SHUTTER
PHOTOTUBE

Figure 6. Schematic diagram of the multivibrator and associated pulse-shaping and limiting circuits used in the shutter-flash synchronizer

OPERATION

As PREVIOUSLY EXPLAINED, when the shutter actuating lever is depressed, the shutter switch makes momentary electric contact. This is followed by the opening of the shutter aperture.

At the instant the shutter switch closes, a voltage is applied to a resistance-capacitance high-pass and mixer circuit, the output from which provides a short triggering pulse to two single-shot multivibrators and to a cathode-ray single-sweep circuit. The leading edge of the voltage output from each multivibrator occurs simultaneously with the triggering pulse, whereas the trailing edge of the output voltage is delayed in time. The delay time is controlled by the position of the time-calibrated dials on the front of the multivibrator chassis previously shown. After differentiating the output voltage from each multivibrator, the resultant negative voltage pulses are erased and the positive pulses, which correspond to the preset delay times, are limited in amplitude and superimposed in the mixer circuit on the phototube amplifier output voltage. The latter voltage is directly related in both time and amplitude to the shutter-aperture-opening characteristic.

The output from the mixer is applied to the vertical deflection amplifier in the cathode-ray oscilloscope.

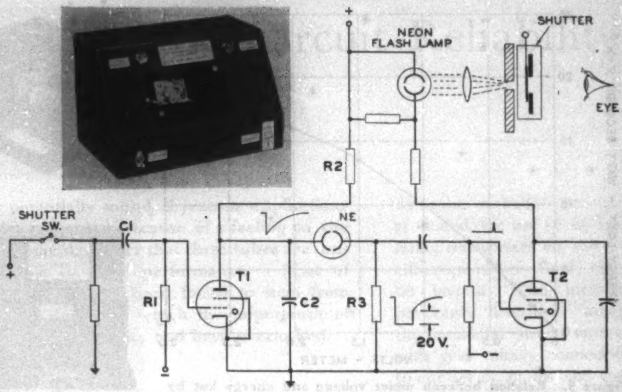

Figure 7 (right). Apparatus and schematic diagram of synchronizer for the production testing of shutters

A schematic wiring diagram of the multivibrator and associated pulse-shaping and limiting circuits is shown in Figure 6. The period of the two independently variable multivibrators is controlled by the calibrated logarithmic potentiometers shown. The multivibrator output voltages are impressed on the capacitor, resistor, rectifier networks (shown on the right), which differentiates the multivibrator output signals, erases the resultant negative pulses, and shapes and limits the amplitude of the positive pulses. These pulses are superimposed on the voltage output from the phototube circuit and the combined outputs, as previously noted, are applied to the vertical amplifier of the cathode-ray oscillograph.

DIRECT-VIEW SHUTTER-FLASH SYNCHRONIZER

A PHOTOGRAPH AND schematic wiring diagram of another type of shutter-flash synchronizer which was developed for the production testing of shutters are shown in Figure 7. Here the instrument is shown set up for testing shutters prior to mounting them in cameras. A neon lamp mounted on the panel behind the shutter flashes momentarily, 2 milliseconds, approximately 20 milliseconds after the contact make of the shutter switch. If the light pulse is visible through the shutter aperture, it indicates that the synchronization between the switch closure and the maximum opening of the shutter aperture is satisfactory.

CIRCUIT OPERATION

WHEN THE SHUTTER SWITCH closes, a positive pulse is applied to the control grid of thyratron *T1* (this tube is normally biased to cut-off), which causes the tube to conduct. Capacitor *C2* is then rapidly discharged by the thyratron and in so doing the anode-cathode potential of the tube is reduced to less than that required to sustain ionization. Capacitor *C2* then charges exponentially with time. When the potential across *C2* equals the breakdown potential of neon lamp (N_e), a positive voltage transient occurs across *R3* which is equal in amplitude to the difference in the potential between the neon lamp breakdown voltage and the steady-state ionization voltage. This voltage difference (approximately 20 volts) is shown as the sharp vertical rise in the trailing edge of the output voltage across *R3*. The voltage across *R3* is then differentiated and applied to the control grid of thyratron *T2*. The neon lamp in the anode of *T2* glows momentarily during the conduction cycle of the thyratron.

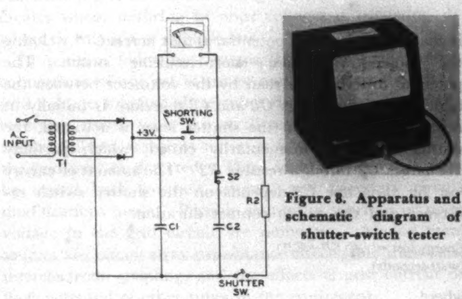

Figure 8. Apparatus and schematic diagram of shutter-switch tester

For shutters designed to be used with photoflash lamps having a 20-millisecond time delay, the neon flash lamp will glow during the interval of approximately 19 to 21 milliseconds.

SHUTTER SWITCH TESTER

Contact Resistance. The accurate synchronization between the shutter switch make and the opening of the camera shutter would be of little value if the total electric energy transferred from the batteries through the switch to the photoflash lamp were not sufficient to cause the lamp to ignite.

If it is assumed that the voltage and the internal resistance of the photoflash batteries and the resistance of the photoflash lamp filament are constant, then the total energy transferred to the lamp from the batteries depends on the average contact resistance of the shutter switch and the total time during which the switch makes contact.

A photograph and schematic wiring diagram of the instrument which is used to test the total equivalent energy transfer and the leakage resistance characteristics of shutter switches are shown in Figure 8.

Operation. A d-c supply, of approximately 3 volts, equal to the battery voltage normally used to ignite photoflash lamps, is obtained by rectifying and filtering the a-c output voltage from the secondary of *T1*.

When the shutter switch is open, *C2* (4,000 microfarads)

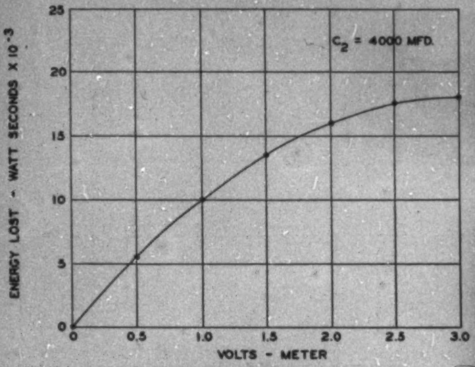

Figure 9. **Relation between meter voltage and energy lost by capacitor C2 in Figure 8**

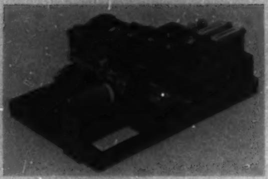

Figure 10. **Three counters are used in this equipment for life testing shutters which are motor driven**

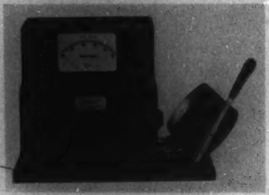

Figure 11. **Shutter light-leakage test instrument**

is charged to the same potential as that across *C1* by closing the momentary make short-circuiting switch. The potential difference as read by the voltmeter between the high side of capacitors *C1* and *C2* therefore is initially at zero. However, when the shutter lever is actuated, the shutter switch is momentarily closed, which partially discharges *C2* through resistor *R2*. The amount of energy lost by capacitor *C2* depends on the shutter switch resistance and the switch contact duration.

Energy lost $= {}^1/_2C(E1^2 - E2^2)$
(watt-seconds)

where

$E1$ = Initial voltage across $C2$
$E2$ = Final voltage across $C2$
C = Farads

The relationship between the voltmeter reading and the loss in energy is shown in Figure 9.

In the production testing of shutter switches, the minimum acceptable meter reading corresponds to an equivalent energy transfer several times greater than that required to ignite photoflash lamps.

Leakage Resistance. The measurement of the leakage resistance in the shutter switch and the photoflash connector socket is also an essential production test. Referring again to Figure 8, if the momentary break switch *S2*, which is assumed to have an infinite leakage resistance, is open, then the current, if any, which flows through the voltmeter would be a measure of the leakage resistance. The quality control standards of one camera manufacturing company require that this current must be less than 5 microamperes, which corresponds to a leakage resistance of greater than 600,000 ohms.

SHUTTER LIFE TEST INSTRUMENT

An instrument for testing the life of shutters is shown in Figure 10. The motor automatically actuates the shutter lever. If the shutter aperture fails to open or if the shutter switch fails to contact when the shutter lever is depressed, then the shutter is considered defective.

Three counters are used in the tester. One counts the number of times the shutter lever is actuated; another counts the number of times light passes through the shutter aperture; and the third counts the number of times the shutter switch closes. In testing a shutter, all counters are initially set at zero. Shutter failure is evidenced by a difference in reading between any of the three counters.

SHUTTER LIGHT-LEAKAGE TEST INSTRUMENT

A shutter light-leakage test instrument is shown in Figure 11. Lamps are located in the cylindrical enclosure on the movable arm. When this arm is raised vertically, an electric contact is made which floods the shutter under test with light. Any light passing through the shutter is picked up by a photomultiplier tube. The output, if any, is indicated on the microammeter shown.

Furnace Dust Recovered

Hundreds of tons of furnace dust containing small quantities of nickel and copper is being recovered by the International Nickel Company of Canada, Ltd., and turned back into production. The dust is recovered from gases from the batteries of roasters and converters in the smelter and is used again in the nickel reverberatories.

On their way to the plant's smoke stack the gases pass into huge flues in the treater section in which are suspended twisted-wire curtains charged with 60,000 volts of electricity. Parallel to the wire curtains are grounded 22-foot rods which act as collecting electrodes. Receiving this electric shock, the ionized particles of dust are precipitated on the rods and the gases pass on to the stack. The dust is knocked off the rods into bins and transported to a tank which blows it through pipes to the furnaces for use again in the smelter reverberatories.

Improving Gas-Tube Grid Circuit Reliability

J. H. BURNETT
MEMBER AIEE

Many potentially sound thyratron applications have been avoided because of a feeling on the part of some designers that these tubes are unpredictable in their performance. Most of these reports have been found to stem from some unit design in which the importance of grid circuit reliability had been overlooked.

SUCCESSFUL designers of electronic equipment utilizing gas-filled thyratron tubes recognize there are important circuit factors to be considered which are often neglected without penalty when using high-vacuum tubes. The degree of success of each application vitally depends on the engineering attention given to the grid circuit. Many potentially sound thyratron applications have been avoided because of a feeling on the part of some equipment designers that such tubes are unpredictable in their performance. When tracked down, most of these reports have been found to stem from some unit design in which the importance of grid circuit reliability had been overlooked. The purpose of this article is to discuss several of the frequently encountered causes of malfunctioning of the grid circuit, how they may be identified in practice, and how their effect on hot-cathode gas tube performance may be minimized.

Numerous basic methods of controlling the firing angle of thyratrons have been described in the literature, and many of these with various modifications are widely used. It is obvious, but can not be too strongly emphasized, that good circuit design provides for satisfactory equipment operation independent of tube replacement, and without circuit adjustment in the field. The more subtle considerations in grid circuit design, however, have not been widely discussed.

DETECTION OF "NOISE"

MODERN THYRATRONS respond faithfully to the actual voltage of the grid with respect to cathode, whether it is a signal voltage, a false signal, or a noise voltage. Naturally, most noise voltages can be filtered by adding sufficient time constant at the grid to average out transient voltages to a negligible degree, but in applications where full advantage is to be taken of the fast response of gas thyratrons, such "brute force" filtering is not tolerable. Therefore, it is desirable to trace back to the source any such undesirable voltages and, having found the cause, apply a remedy which does not add excessive time constant.

A cathode-ray oscilloscope with a d-c amplifier is indispensable in all phases of grid circuit development, and especially for the detection of noise. Since appreciable capacitance between the oscilloscope power supply and its signal ground terminal may distort the grid voltage if the tube cathodes are ungrounded, the use of an isolating transformer for the oscilloscope power supply may be helpful. The method previously described,[1] using the horizontal sweep setting with grid voltage connected so one set of plates and the anode voltage connected to the other set for viewing instantaneous grid and anode voltages, is convenient, and indicates where misfiring by noise voltages is occurring, or where the margin of safety is low.

In position follow-up systems, by opening the anode connections of one set of tubes, and analyzing the actual grid voltage supplied these tubes during the firing of the reversing tubes, with the oscilloscope brilliance control turned full on, transient noise or false signal voltages on the grid may be detected. These noise voltages may then be traced back to their sources, and necessary circuit modifications made. Possible sources of spurious or noise voltage in the grid circuit are numerous. Among these sources are circuit stray capacitance effects, line transients, interelectrode coupling, and the effects of grid current or float potential of other tubes in the equipment.

CIRCUIT STRAY CAPACITANCE EFFECTS

BY FAR THE MOST common source of noise voltage, and often the source overlooked, is the transient charging or discharging of stray capacitance between grid transformer windings and between these windings and ground

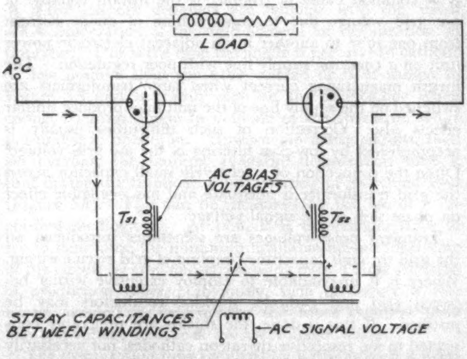

Figure 1. Typical path of transient charging current through circuit stray capacitances, when thyratrons are connected back-to-back

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J. H. Burnett is with Electrons, Inc., Newark, N.J.

through relatively high grid circuit impedance, producing on the grid unwanted voltages of extremely large magnitude and short duration. A typical offender is the "back-to-back" connection where the cathodes are exposed to both line and load potential surges. Figure 1 shows thyratrons so connected as they may be for either a reversing servo, an X-ray contactor, welding control, or for lighting dimmer control. This effect also may be found in servos where the forward and reverse circuits are linked only by stray capacitance between transformer windings, or when supplying separate reversing fields with common magnetic linkage. The effect also may occur when line switches are closed in such circuits with the resulting sudden charging up of grid circuit stray capacitances to ground.

In Figure 1, consider conditions existing with a slightly inductive load at the end of conduction of one tube. Conduction continues past the end of the cycle for a few degrees due to load inductance. The cathode-to-anode voltage across this tube suddenly changes from tube voltage drop, of about 10 volts, to the instantaneous line voltage. A charging current then flows into the stray capacitances indicated, through part of the grid circuit impedance of the other tube, producing a voltage of short duration, but considerable magnitude. This has a polarity to raise the actual grid voltage above the critical grid voltage and misfire the tube.

Such effects may be minimized by including static shields around each grid transformer winding and connecting each shield to the respective thyratron cathode. Often, a small capacitor across the grid transformer secondary, or the use of lower impedance grid transformers, reduces such noise to a tolerable degree without static shields. If it is desirable to hold the control-tube cathodes at common potential for either a-c load control, or d-c half-wave reversing control, without the cost of an anode transformer, two thyratrons and two diodes may be connected as in Figure 2.

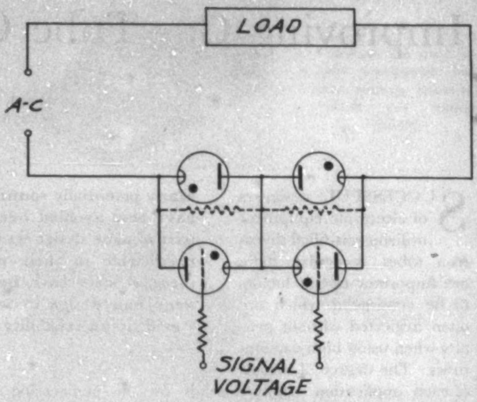

Figure 2. Variable a-c load, or d-c load reversing control with thyratron cathodes at common potential, convenient when signal voltage is direct current

LINE TRANSIENTS

An obvious source of noise, although not the most common cause of trouble, is the instant collapse of a-c grid voltage due to commutation of anode current from one tube to another in an adjacent electronic power unit on a common supply line with poor regulation. The inrush magnetizing current when large transformers are switched on the supply line of the unit may produce similar effects also. Correction of such difficulties usually is accomplished by low-pass filtering of the a-c grid voltage. Often the connection of a relatively small capacitor across the grid transformer is adequate and has negligible effect on phase shift of the signal voltage.

Transient noise voltages are sometimes introduced on the grid through capacitive coupling of grid circuit wiring. Where it is unavoidable to employ extensive wiring between grid and cathode, shielded conductors may be justified. If this is done, the shields are preferably connected to the respective thyratron cathodes, not necessarily ground. Short grid leads are always advisable and it is especially desirable to connect the grid resistor as close as possible to the tube. It is usually worth while to check the effect on circuit noise of various possible cathode-to-ground voltages on an ungrounded chassis.

INTERELECTRODE COUPLING

Transient grid voltages induced through interelectrode capacitances in the tube (Figure 3) may be limited to a negligible value by connection of a small padding capacitor (usually 0.005 microfarad or less) directly from grid to cathode of each tube. The use of such a capacitor results in an effective capacitance ratio of anode-to-grid grid-to-cathode of several hundred, and therefore limits maximum transient grid voltages so induced to a small fraction of a volt. The time constant of padding capacitor and grid resistor must be limited to

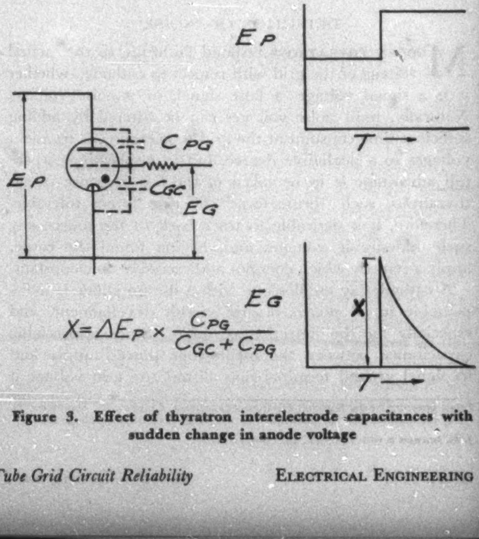

Figure 3. Effect of thyratron interelectrode capacitances with sudden change in anode voltage

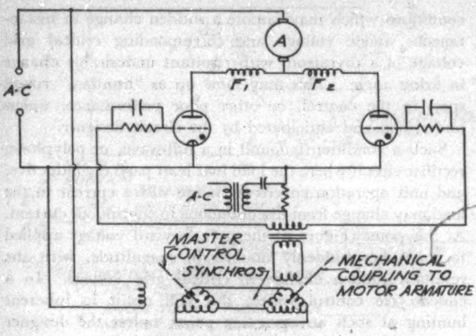

Figure 4. **Grid self-rectified bias, for improved stability in a typical positioning servo**

an insignificant fraction of a cycle to minimize carry-over effects.

CRITICAL GRID CHARACTERISTICS

In most of the basic commonly used methods of control, the stability and uniformity of the thyratrons being used will determine usually the minimum practical signal voltages, and hence the sensitivity of the power amplifier unit.[2] Consideration of the maximum range of grid characteristics including the maximum range of critical grid voltage and starting voltage, of all tubes of a given type over their useful life and full ambient temperature range is the basic starting point in grid circuit design as it fixes the magnitude of signal voltage required, regardless of tube replacement.

As the grid voltage is reduced to fire the tube, the greatest value of current which flows to the negative grid just prior to firing is defined as the maximum critical grid current. This current flows in a direction to make the grid less negative, or in a sense may be considered to make the apparent critical grid voltage correspondingly more negative than the true critical grid voltage. Since the critical grid current after cycles of heavy conduction may be greater than on the first cycle, the maximum value, not the "preconduction" grid current, is necessary for careful circuit design. Most modern tubes have so low a critical grid current at 60 cycles that circuit insulation leakage currents to be expected in usual industrial practice may be the limiting condition. However, since the critical grid current increases rapidly with frequency, this consideration becomes much more important above 60 cycles, and manufacturer's data should be studied. On the other hand, in modern tubes up to several thousand cycles the effect of frequency on critical grid voltage is minor.

Proper impedance matching is important as in any electric circuit design. The impedance of the grid driving circuit is usually made relatively lower than the grid limiting resistance, to avoid distortion and phase shift of the signal voltage through regulation caused by loading, and to avoid carry-over effects. The upper limit of grid resistance is usually set at a value which sufficiently minimizes voltage drop with a maximum critical grid current, or leakage current flowing through it.

During anode conduction, the grid under most conditions floats at a potential within a few volts of cathode potential. As a result, current may flow through the grid circuit during this period. This current may store energy in a grid circuit component. If the stored energy is dissipated too slowly after conduction ceases, it will appear as a fictitious signal on the following cycle. This may appear as a tendency for the tubes to flicker instead of turning on sharply, to pass several cycles when the signal voltage calls for only one cycle, or irregularity in the control curve.

It is also desirable to recognize the effect on a tube about to fire, caused by flow of grid current to another conducting tube through a common grid circuit impedance. The actual grid voltage of the first may be materially affected by the float potential of the grid of the conducting tube. This can occur in a full-wave or polyphase rectifier, as well as in a reversing circuit.

Self-rectified current in the grid circuit may provide a useful form of d-c bias by the transient charging of a small by-pass capacitor connected across the grid resistor. Figure 4 shows a positioning servo combining a variable a-c signal with fixed lagging a-c grid bias and incorporating such a self-bias scheme. With large error signal, the total a-c grid voltage will be large in magnitude and nearly in phase with the anode voltage. By use of self-bias, the first cycle of full conduction results in charging the by-pass capacitor negatively. The firing angle on the succeeding cycles will be retarded more than the signal voltage indicates by an amount equal to the negative bias on the by-pass capacitor. As this charge leaks off over several cycles, signal sensitivity is gradually regained. The effect is to desensitize the circuit when signals are large and thereby minimize hunting. This stabilizing effect may be desirable in some closed cycle systems where, for example, the overall time constant is in the order of several cycles, while the tubes respond almost instantaneously.

MEASUREMENT OF DEIONIZATION TIME

Most circuit designers are familiar with the usual observation of the time allowed for deionization of the tube. This is the time the anode is negative to cathode or less positive than the tube voltage drop as shown in Figure 5*A* and is readily seen on the oscilloscope when connected from anode to cathode of the thyratron while the unit is in operation. However, in many circuits, such as inverters, the limiting available deionization time is that during the transient of unit starting or switching load (Figure 5*B*). This can be measured by the use of a recording oscillograph. At best, it is exceedingly risky to try to determine the minimum available deionization time of the circuit by trial and error, using even a large selection of production tubes. Obviously, such procedure is also to be avoided in determining the tubes required peak forward voltage and peak inverse voltage ratings.

The deionization time required by a thyratron is a function of anode voltage, grid voltage, and current magnitudes. Incipient failure to deionize shows up as an apparent

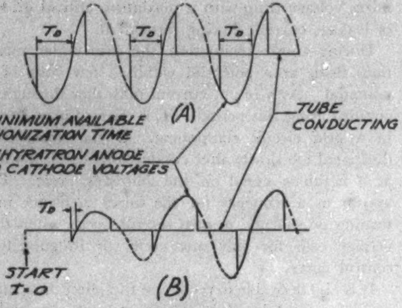
To
To
To
To = MINIMUM AVAILABLE DEIONIZATION TIME
(A)
TUBE CONDUCTING
THYRATRON ANODE TO CATHODE VOLTAGES
To
START T=0
(B)

Figure 5. Available deionization time

A—Full-wave rectifier with inductive load in the steady state
B—Limiting transient starting conditions in a parallel inverter

increase in critical grid current. Grid circuit impedance and voltage are important factors therefore, in determining the upper frequency limits of reliable operation. In fact, the tubes deionization time rating is often specified as measured under definite grid and anode circuit conditions.

FEEDBACK OR REFERENCE VOLTAGE DISTORTION

IN CLOSED-CYCLE control systems, the feedback voltage should be well filtered to avoid various types of tube unbalance and hunting. Distortion of either the reference voltage, or a-c sinusoidal grid bias voltage, also may be troublesome. For example, in a regulated d-c supply consisting of a single-phase full-wave grid control rectifier, under some conditions of insufficient feedback filtering, if one tube conducts earlier and longer than its mate the instantaneous increase of output voltage will tend to hold off the other tube more than the average output of the two tubes would indicate, and the unbalance between tubes increases still further. Under other conditions of improper filtering in such a circuit, the distortion of feedback voltage may cause first one tube, then the other, to take up the load or both tubes to come on together and then shut off completely. Such effects are usually observed to be the result of inadequate attention to the feedback or reference voltages or their vacuum tube preamplifier circuits. The plate supplies of the latter may introduce undesirable results through the transient charging of unbalanced stray capacitances to ground.

If the feedback loop is opened, and a battery with potentiometer across it substituted for the feedback and reference voltages and the preamplifier, adjustment of the control unit can be made to overcome other difficulties, and then the reference and feedback voltages added in separate steps until the cause of trouble is isolated.

POWER-CIRCUIT LIMITATIONS

CERTAIN inherent power-circuit characteristics may cause undesirable effects which at first glance are sometimes erroneously attributed to grid circuit noise. There are a number of commonly encountered circuit conditions which may impose a sudden change in instantaneous anode voltage and corresponding critical grid voltage of a thyratron, with resultant undesirable change in firing angle. This may show up as "hunting," rough spots in the control, or other poor performance, unless understood and anticipated by the circuit designer.

Such a condition is found in a full-wave, or polyphase, rectifier circuit where the load is at least partially inductive, and unit operation covers the range where current in the load may change from discontinuous to continuous current. At this point (Figure 6) the peak forward voltage applied to the tubes suddenly doubles in magnitude, with the resultant sudden change in critical grid voltage. In a closed-cycle control system this will result in inherent hunting at such an operating point, unless the designer has provided a grid circuit voltage which minimizes the effect.

Another circuit condition which produces a sudden change in critical grid voltage is the double 3-phase rectifier circuit with interphase reactor, operating at light load.

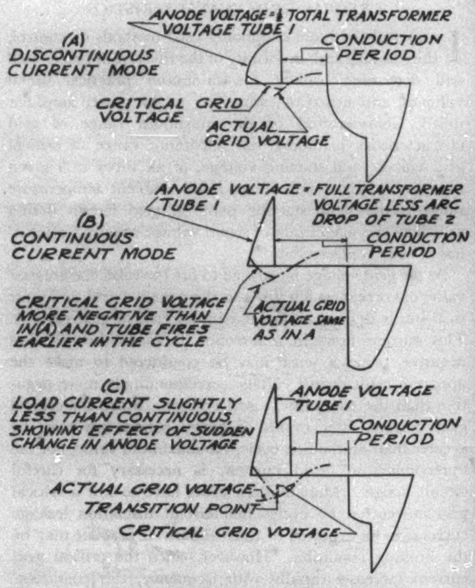
ANODE VOLTAGE = ½ TOTAL TRANSFORMER VOLTAGE TUBE 1
(A) DISCONTINUOUS CURRENT MODE
CONDUCTION PERIOD
CRITICAL GRID VOLTAGE
ACTUAL GRID VOLTAGE
ANODE VOLTAGE = FULL TRANSFORMER VOLTAGE LESS ARC DROP OF TUBE 2
TUBE 1
(B) CONTINUOUS CURRENT MODE
CONDUCTION PERIOD
CRITICAL GRID VOLTAGE MORE NEGATIVE THAN IN (A) AND TUBE FIRES EARLIER IN THE CYCLE
ACTUAL GRID VOLTAGE SAME AS IN A
(C) LOAD CURRENT SLIGHTLY LESS THAN CONTINUOUS, SHOWING EFFECT OF SUDDEN CHANGE IN ANODE VOLTAGE
ANODE VOLTAGE TUBE 1
CONDUCTION PERIOD
ACTUAL GRID VOLTAGE
TRANSITION POINT
CRITICAL GRID VOLTAGE

Figure 6. Various modes of operation of full-wave rectifier showing effects on anode and critical grid voltages

A—Discontinuous load current
B—Continuous load current
C—Transition from A to B with typical inductive load

As the output current is reduced to a low value, the voltage generated in the interphase reactor no longer is great enough to sustain current conduction through each tube for as long as 120 degrees and the mode of operation suddenly changes from double 3-phase (120-degree tube

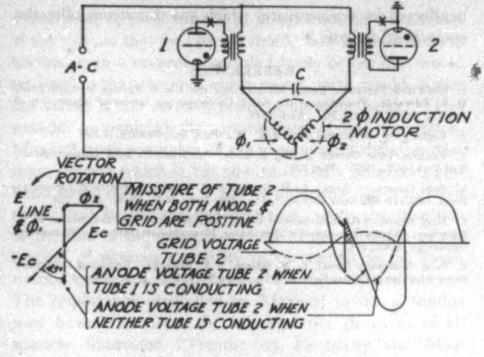
1
2
A-C
C
2 ϕ INDUCTION MOTOR
ϕ1
ϕ2
VECTOR ROTATION
E LINE & ϕ1
ϕ2
Ec
-Ec
45°
MISSFIRE OF TUBE 2 WHEN BOTH ANODE & GRID ARE POSITIVE
GRID VOLTAGE TUBE 2
ANODE VOLTAGE TUBE 2 WHEN TUBE 1 IS CONDUCTING
ANODE VOLTAGE TUBE 2 WHEN NEITHER TUBE IS CONDUCTING

Figure 7. Anode-voltage phase shift in one type of a-c motor servo circuit during conduction of reversing tube

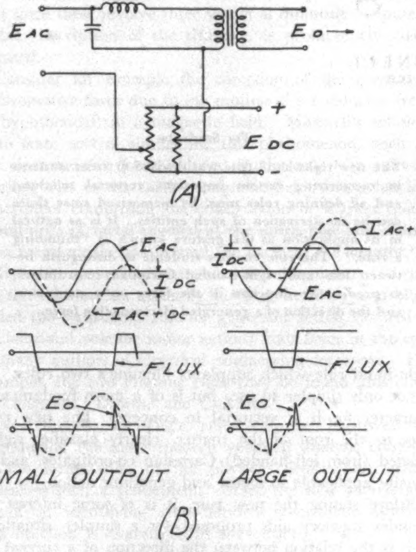

Figure 8. Phasable peaking voltage source

A—Typical circuit
B—Waveforms of flux and voltages

conduction) to 6-phase star (60-degree tube conduction) with a resultant sudden change in peak forward voltage and the corresponding critical grid voltage on all tubes at a given firing angle.

In position follow-up servos, employing either d-c armature or field voltage reversing, the instantaneous anode voltage on the "off" tube or tubes is the sum of the anode transformer voltage and the voltage appearing across the load due to motor rotation, or because of conduction of the "on" tubes. It will include any "hash" from the commutator. In some a-c motor reversing circuits, the actual anode voltage of the off tube may be the voltage across the phase-splitting capacitor hence of different phase angle from the line voltage (Figure 7). In these cases the actual anode voltage may be positive during a large part of the cycle when the anode voltage would normally be negative if the servo signal voltage is zero. Negative d-c bias plus pulse firing is one solution in such cases to avoid misfiring. Numerous peaking voltage sources are available if required for any of these applications.

A few simple schemes for obtaining useful peaking voltages which may be phase shifted are shown in Figures 8 and 9. Figure 8 illustrates the use of a standard transformer operated from an alternating voltage higher than its normal rating through a series impedance with phase shift obtained by varying the magnitude and polarity of a d-c control voltage in series with the a-c supply. Figure 9 shows two schemes for producing a peaking voltage where the slope need not be very steep but where a single voltage peak per cycle is desired. Phase shift of the a-c input voltage to either of these networks may be accomplished by combining a variable magnitude and direction a-c signal voltage with a fixed magnitude alternating voltage which lags the signal voltage in the order of 150 degrees.

Other methods of obtaining peaking voltages which have been described previously include a variable-phase input to a vacuum-tube multivibrator; a variable-phase input to an overdriven amplifier combining saturation limiting and cutoff limiting, and the resulting square-wave output differentiated;[3] a variable d-c magnitude and polarity input to a self-blocking vacuum-tube oscillator having a small magnitude a-c bias lagging the thyratron anode voltage approximately 90 degrees;[4,5] a phasable pulse as a result of suddenly reducing the current in a linear

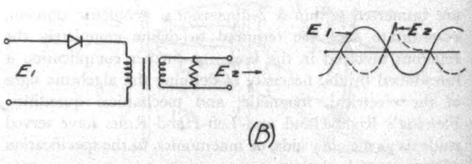

Figure 9. Two simple means of obtaining a peaking voltage

A—Addition of full-wave rectified voltage and 90-degree phase-shifted alternating voltage
B—Secondary voltage of a standard audio transformer with half-wave rectified current in the primary

inductance to zero by cutting off a vacuum tube in series with the inductance, directly or by means of associated capacitances and nonlinear inductance[6]; applying interrupted direct current to the primary of certain grid transformers to produce a peaked secondary voltage.

CONCLUSION

MANY SUCCESSFUL equipment designers report encountering some, or all, of the foregoing considerations. Therefore, in unit design a careful engineering analysis of the circuit along these lines is advisable to assure reliability of operation over a long life, and full realization of the fast response, and compact amplification unaffected by temperature, which gas thyratrons offer the equipment designer.

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A New Universal Right-Hand Rule

P. M. HONNELL
MEMBER AIEE

For Instructors

The introduction of students to magnetic fields and to electromagnetic-mechanical reactions should be concurrent with the arbitrary definitions of co-ordinates for the directed physical quantities. This conserves the time and energy of the instructor and students alike. The single new rule described supersedes both of Fleming's hand rules (dated 1885). It substantially reduces errors in applications, for students need remember only which is their right hand!

For Students

The new right-hand rule was devised to assist students in memorizing certain important vectorial relations; and all defining rules must be memorized since there can be no derivation of such entities. It is as natural in its application as the gesture known as "thumbing a ride." The rule enables students to distinguish between left- and right-handed Cartesian co-ordinates; to predict the direction of the force on a conductor; and the direction of a generated electromotive force.

THE FUNDAMENTAL physical laws commonly (but not quite precisely) expressed by the $e=Blv$ and $f=Bli$ equations relating an electric circuit, a magnetic field structure, and a mechanical circuit, are applicable to rotating machinery, to the driving element of a dynamic loudspeaker, or to the deflections of electronic beams in cathode-ray tubes. Being of so fundamental a character, these laws therefore should be well understood by all electrical engineering students.

Since the electric, magnetic, and mechanical circuits are immersed within a 3-dimensional geometric domain, co-ordinate axes are required to define completely the relations involved in the laws. A further complication is introduced by the necessity of defining the algebraic signs of the electrical, magnetic, and mechanical quantities. Fleming's Right-Hand and Left-Hand Rules have served students as memory aids, or mnemonics, in the specification of these spatial relations.

The purpose of this article is to describe a single new right-hand rule which supplants Fleming's two rules. It is not only simpler to use, but is of a more fundamental character for it is vectorial in concept. The new rule goes to the root of the matter, clearly classifies right-handed (from left-handed) Cartesian co-ordinates, and is equally applicable to motor and generator action.

Before stating the new rule, it is of some interest to consider memory aids proposed for a simpler situation. This is the relation between the direction of a current of electricity and the resulting magnetic flux. According to Mauduit[1] a quaint mnemonic rule, presumably due to Ampère himself, and therefore historically one of the earliest on this subject, reads: "Règle du bonhomme d'Ampère: Le flux se dirige de droite à gauche pour un observateur couché sur le conducteur, regardant vers l'intérieur du circuit et recevant le courant par les pieds." ("The rule of Ampere's little man: The flux is directed from right to left for an observer lying on the conductor, facing the interior of the circuit, and receiving the current through his feet.")

The rule was restated by Maxwell[2] for an indefinitely long straight wire carrying an electric current, as: "If

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a man were to place himself in imagination in the position of the wire, so that the current should flow from his head to his feet, then a magnet suspended freely before him would set itself so that the end which points north would, under the action of the current, point to his right hand." Presumably recognizing the awkwardness of this description, Maxwell gives a number of other equivalent defining relations, among which is his now universally adopted right-hand screw rule:[3] ". . . a line of induction passes through the circuit in the positive direction, when the direction of the line of induction is related to the direction of the current of vitreous electricity in the circuit as the longitudinal to the rotational motion of a right-handed screw." The importance attributed by Maxwell to this definition may be inferred from the fact that two drawings of his sparsely illustrated "Treatise on Electricity and Magnetism" are devoted to this matter.[4]

From the foregoing examples, it is evidently difficult to express, in words only, the definitions of positive directions for but two vectorial quantities. Returning to the more complicated laws under consideration, it is clear that since these involve three vectorial quantities, a purely verbal description of the situation is prohibitively complicated.

Consider for example the direction of the generated electromotive force due to the motion of a conductor (real or hypothetical) in a magnetic field. Maxwell's solution is to state several similes for this phenomenon, such as the electromotive force induced in the axle of a railway carriage due to the earth's magnetic field, and a fanciful experiment comprising the construction of a great quadrantal arch of metal pivoted at the north pole and sliding on a metal girdle laid around the earth at the equator.[5]

It is not surprising, therefore, that the mnemonic rule for this relationship given by Fleming in 1885,[6] and often called the right-hand rule for generator action, (as well as his left-hand rule for motor action) finds favor in the eyes of many authors of electrical engineering textbooks. For example, the two Fleming rules may be found illustrated in Langsdorf,[7] Dawes,[8] and Cullwick.[9]

Nevertheless, Fleming's rules can be improved by introducing the more modern vectorial analysis concepts in the formulation of the physical laws. This article describes such a refinement. Since the new rule is also useful in identifying right-handed co-ordinate systems, this function is established at the outset.

RIGHT-HANDED CO-ORDINATES IN SPACE

VECTORIAL expressions are conventionally defined in a right-handed system of spatial axes, and it is desirable to provide a means for specifying this relationship. This is done in Figure 1. A right-handed system relates the x, y, and z Cartesian co-ordinates in the 1, 2, 3 spatial relation shown in the illustration. These spatial relations may be remembered by extending the fingers in the direction of the forearm, which gives direction 1; the four fingers are then flexed at right-angles to the palm in the natural direction, which gives direction 2; and finally the erect thumb points in direction 3. This defines the x, y, z axes of a right-handed co-ordinate system.

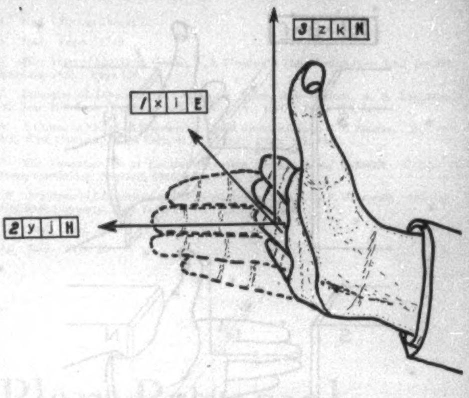

Figure 1. The spatial arrangement of a right-handed co-ordinate system with the cyclical order 1, 2, 3

Similarly, the unit vectors **i**, **j**, **k** of vectorial analysis form a right-handed system if they are in the spatial cyclical order 1, 2, 3 indicated in Figure 1. The new hand rule naturally applies here again as a memory aid.

THE ELECTROMOTIVE-FORCE RULE

A PHYSICAL (or mathematical) line conductor moving with a linear velocity $\dot{\mathbf{x}}$ within and relative to a magnetic field of density **B** generates an electromotive force **E**. The physical quantities involved are taken as

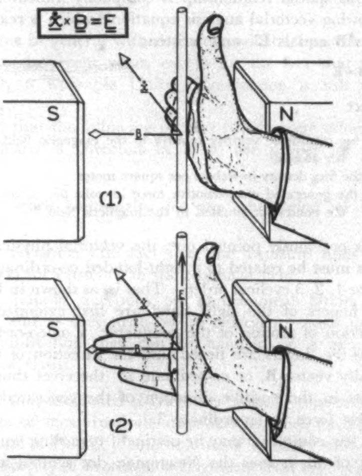

Figure 2. The generated-electromotive-force rule

$\dot{\mathbf{x}}$ is the conductor velocity relative to the magnetic field in meters per second
***B** is the flux density in webers per square meter*
***E** is the generated electromotive force in volts per meter length of the conductor in the field*

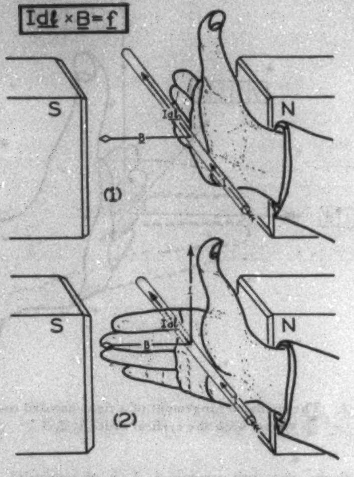

Figure 3. The mechanical-force rule

I is the current in amperes through the conductor

dl *is an element of length of the conductor taken in the direction of motion of the positive current of electricity (or its equivalent)*

f *is the mechanical force in newtons per meter length of the current-carrying conductor situated in the magnetic field, relative to the structure supporting the magnetic field*

positive when they are in the 1, 2, 3 spatial relationship of a right-handed co-ordinate system.

This spatial relationship is compactly indicated by the following vectorial analysis equation[10] which is read "dot-**x** cross **B** equals **E**" and written:

$$\dot{\mathbf{x}} \times \mathbf{B} = \mathbf{E} \tag{1}$$

where

$\dot{\mathbf{x}}$ is the conductor velocity relative to the magnetic field in meters per second
B is the flux density in webers per square meter
E is the generated electromotive force in volts per meter length of the conductor situated in the magnetic field

As previously pointed out, the vectorial physical quantities must be related to a right-handed co-ordinate system in the 1, 2, 3 cyclical order. That is, as shown in Figure 2, the fingers of the right hand are first extended in the direction of motion of the conductor, $\dot{\mathbf{x}}$ or co-ordinate 1; next, the fingers are flexed into the direction of the flux-density vector **B**, or co-ordinate 2; the erect thumb then points in the positive direction of the generated electromotive force **E**, co-ordinate 3.

A few comments may be pertinent regarding equation 1. First of all, it uses the Newtonian dot symbol $\dot{\mathbf{x}}$ for the velocity *dx/dt*. This relieves the excessive overloading, in electrical writings, of the symbol "*v*." Secondly, it is clear that the full significance and utility of the vectorial expression 1 in cases of nonorthogonal spatial relations of the vector quantities will not be apparent to the beginning student. He is nevertheless perfectly capable of remembering and using it as in the present instance; and the full meaning will develop gradually with the student's continued studies.

THE MECHANICAL-FORCE RULE

The mechanical force on a conductor carrying a current of positive electricity (or its equivalent) immersed in a magnetic field is given by the vectorial expression:[11]

$$I\mathbf{dl} \times \mathbf{B} = \mathbf{f} \tag{2}$$

where

I is the current magnitude in amperes through the conductor
dl is an element of length of the conductor taken in the direction of motion of the positive current of electricity (or its equivalent)
f is the mechanical force in newtons per meter length of the current-carrying conductor within the magnetic field, relative to the physical structure supporting the magnetic field

The space vectors representing the physical quantities are related to a right-handed co-ordinate system in the cyclical order 1, 2, 3. This is shown in Figure 3 in which the fingers of the right hand are first extended along the direction of the current element *I* **dl** in the proper sense, giving co-ordinate 1; the fingers are then flexed into the direction of the flux density vector **B**, co-ordinate 2; the erect thumb then naturally points in the direction of the developed mechanical force **f** which acts between the mechanical structure supporting the magnetic field and the current-carrying conductor.

DIRECTION OF PROPAGATION OF AN ELECTROMAGNETIC WAVE

As a final application of the new right-hand rule and again emphasizing its vectorial character, consider the direction of propagation of free or guided electromagnetic waves. The electric field, magnetic field, and direction of propagation, form a spatial vectorial relation as expressed[12] by:

$$\mathbf{E} \times \mathbf{H} = \mathbf{N} \tag{3}$$

where

E is the electric field intensity in volts per meter
H is the magnetic field intensity in amperes per meter
N is the power flow in watts per square meter in the direction of propagation of the wave

The **E**, **H**, and **N** vectors representing the physical quantities must again be taken in a 1, 2, 3 cyclical order of a right-handed co-ordinate system, as shown in Figure 1.

CONCLUSIONS

The simplified right-hand rule described herein is based directly upon the vectorial relations involved in the electromagnetic phenomena. Its simplicity lies in: 1. defining a right-handed co-ordinate system in a 1, 2, 3 cyclical order and co-ordinating it with the natural motions of the right hand; 2. writing the physical laws in vectorial form, in which the relative positions of the symbols in the equations is meaningful, as distinct from ordinary algebraic expressions; and finally, 3. in identifying the vectorial symbols representing the electromagnetic-mechanical reactions with the respective spatial co-ordinates.

Experience in the classroom over a period of years, alike with electrical and nonelectrical students, has demonstrated the superiority of the new mnemonic rule.

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A New Unity Plan Proposal

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Editor's Note: This article is published because it represents the views of a large group of members. Publication does not constitute endorsement by the Institute, which will continue to work through Engineers Joint Council toward a Unity Organization.

Although there is general agreement among engineers on the need for unification and a number of plans have been proposed, as yet no one of these has received the full support of the profession. The Unity Organization outlined in this article is suggested by the Pittsfield General Electric Engineers Association as a possible solution.

ALMOST 200 YEARS AGO the original 13 American Colonies faced the vital problem of uniting among themselves and, as a matter of practical necessity, compromised their various differences and jealousies in a Constitutional Convention which produced the Constitution of the United States of America—a document universally recognized as an outstanding landmark in the field of government.

For many years engineers have sought to realize unity in the engineering profession. The latest attempt, Plan *A* proposed by the Engineers Joint Council (EJC) Exploratory Group, has so far achieved only partial success, although most of the societies have not had an opportunity to decide on whether or not to join the Council.

Why is it that engineers have failed so often to achieve this goal which is so desirable from the standpoint of both society and the individual engineer? It is a difficult question to answer. Perhaps the force of external circumstances has not been great enough to cause the principal groups involved to compromise and yield some of their individual independence and freedom of action to a single higher authority. Perhaps past attempts have mistakenly insisted upon society membership instead of individual membership, and thus failed to obtain the full support of individual engineers. Perhaps mutual mistrust between supervisory and nonsupervisory engineers, and organized and unorganized engineers, has contributed to the difficulties of the situation. Certainly many of the best brains in the profession have worked long and arduously on the problem without success.

We agree in general with the actions of the Institute on this matter in recent years, except for the fact that unfortunately a workable Unity Organization is still unrealized.

We feel that the following policies (which were adopted by the Board of Directors in 1950) are proper for the Institute:

1. To work continually for the unification of the profession.

2. To recognize the fact that the Institute finds its chief reason for existence in the technical field.

3. To handle questions on nontechnical affairs as necessary and as they arise on an emergency basis until through unification they can be handled on a general professional basis.

We feel that the Board of Directors properly represented the desires of most Institute members in twice favoring the proposal of Plan *C*, a combination of the EJC with the National Society of Professional Engineers (NSPE), including revisions of both constitutions, as the Unity Organization, rather than the Plan *A* proposed by the Exploratory Committee.

We are pleased to note that AIEE President Quarles has recognized the importance of the unity question in his

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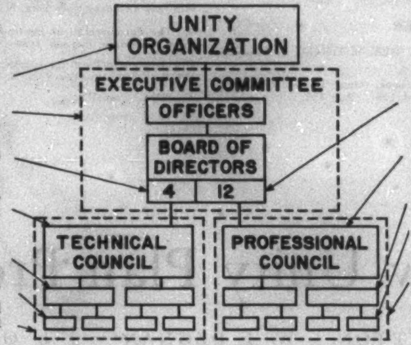
UNITY ORGANIZATION PROPOSAL

By

General Electric Engineers Association

(Bridgeport, Fort Wayne, Lynn, Pittsfield, Schenectady, and Syracuse)



An organization to speak for the engineering profession.

Executive Committee conducts active business of organization. Meets monthly.

4 Directors elected from Technical Council by Council. Serve 2 years. 2 elected each year.

Technical Council similar to Engineers Joint Council. To deal with national technical matters.

Existing technical societies.

Local chapters of technical societies.

This portion of organization would be very similar to present EJC and existing technical societies.

12 Directors elected from Professional Council by Council. Serve 2 years. 6 elected each year.

Number on Council from states proportional to number of members (minimum of 1 per state). Approximately 3 meetings per year.

State societies.

Local chapters.

This portion of organization would be very similar to the present National Society of Professional Engineers.

A. Membership

1. Professional Engineer (those who meet or have met the Salary Stabilization Board qualifications).
2. Scientists (such as physicists, chemists, metallurgists) with educational and experience requirements similar to Salary Stabilization Board qualifications for engineers.
3. Engineers and scientists in training.
4. Students.

B. Financial

1. Dues from individual members.
2. Technical societies to support the Technical Council.

C. Committees

1. Standing committees shall exist to perform functions of public, organizational and internal affairs. Some of the major committees would be Education, Legislative Affairs, Public Relations, Publications, National Defense, Economic Status, Civic Affairs, and Ethics.
   - (*a*) Standing committees shall exist at the national, state, and local levels.
   - (*b*) National committees shall be appointed by the Executive Committee.

Such an organization is designed to include *all* members of the engineering profession with the maximum of participation by the members at the local level in shaping policies. The governing body should represent the viewpoints of all parts of the profession and be directly responsible to the individual members, rather than through other societies. Activities should include economic matters in addition to technical, professional matters.

addresses at the recent General meetings of the Institute.

As members of the Pittsfield General Electric Engineers Association (a nonunion organization), the authors also have long been interested in unity and previously discussed some of our views in a letter to the editor (*EE, Jun '52, p 581*). In response to a suggestion from an individual member of the Exploratory Group and also at the suggestion of the General Electric Engineers Association's Interworks Co-ordinating Committee, the National Societies Committee of the Pittsfield Association has endeavored to plan an organization to fit the needs of the profession as we understand them today. This was done with the following requirements in mind:

1. To plan an organization consistent with the "Five Principles" considered as essential by General Electric engineers in a poll conducted in December 1951. These principles, which received 85–95-per-cent support, are summarized as follows: The Unity Organization should include all members of the engineering profession with the maximum of participation by the members at the local level in shaping policies. The governing body should represent the viewpoints of all parts of the profession and be directly responsible to the individual members, rather than through other societies. Definite consideration should be given to the economic as well as the professional status of the engineer.

2. To propose an organization which, assuming that the various groups of the profession approach the matter with a sincere spirit of co-operation and sacrifice, could be realized in a reasonably short time.

3. To attain unity through the modification or combination of existing organizations and to do this in such a way that the resulting organization would be definitely recognized as *the* Unity Organization. (A large overriding organization, while considered as ideal by some, appears too difficult to attain in any reasonable time and was, therefore, not considered seriously at this time.)

The resulting plan,*† as shown in the diagram, has the following important advantages: (Note: The committee members active in formulating this plan are not members of the NSPE although one is a Registered Professional Engineer).

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* The block diagram and notes shown in this article are the latest revision of the plan. The original plan was modified slightly at the General Electric Engineers Association's Interworks Co-ordinating Committee meeting in January 1953. The original plan is described in the Fall 1952 issue of the *Massachusetts Professional Engineer*. Principal changes are

1. Professional Council was formerly Board of Directors.
2. Board of Directors was formerly the Trustees.
3. Membership grades were previously Professional Registered Engineer (only grade eligible to hold office), Engineer (eligible for registration but unregistered), Engineer-in-training, Student engineers.

1. This plan provides an organization which will include all engineers.

2. The Board of Directors is the governing body and 75 per cent of its members are from the Professional Council which is elected by the membership of the state and local chapters.

3. Provided that the members exercise their voting rights and responsibilities, the organization will be democratic and representative of the profession since the membership of the Professional Council is distributed according to the membership strength of the state societies (for example, one director per state plus one director for each 1 per cent of the total membership).

4. The technical societies are included in the Unity Organization by means of the Technical Council. They can continue their activities as at present, since no important changes are required.

5. The plan does not tie the various groups of the profession together so tightly as to be cumbersome, yet it brings together the principal engineering organizations.

6. The Executive Committee provides a small body to conduct the active affairs of the organization and provides for directors from both the Professional Council (12) and the Technical Council (4), thus representing all viewpoints.

7. The 2-year term for directors and the election of half the directors each year assures continuity of activity in the organization.

A survey questionnaire** was distributed to all engineers at General Electric Plants in Schenectady, N. Y., Fort Wayne, Ind., Lockland, Ohio, Syracuse, N. Y., Lynn, Mass., Pittsfield, Mass., Philadelphia, Pa., and Bridgeport, Conn., to survey the reaction of engineers at all levels to this general form of plan. The number of ballots distributed was 4,982. The results are shown in Table I and predominant comments are noted in the following with certain explanatory notes in parentheses:

1. The restriction of office holding to Registered Engineers (part of the original proposal) received much unfavorable comment. (As now planned there is no such restriction.)

2. There was concern as to the participation or lack of participation of the Unity Organization in collective bargaining. (The plan does not include collective bargaining. The recent trend toward collective bargaining by engineers has caused much concern within the profession. Although we do not feel that collective bargaining is the answer to the problems of most engineers, we definitely recognize that there are situations which make such action necessary. We believe that the objectives and activities of the Unity Organization must be far broader and more comprehensive than those of collective bargaining groups. As we see it, the Unity Organization would be a basic organization covering the professional interests which all engineers share in common, and local groups could have separate organizations if they felt them to be necessary. Coexistence with engineers belonging to both organizations seems quite feasible.)

Table I

Works	Per Cent Returned	Per Cent Yes	Per Cent No
Pittsfield	67	84	14
Syracuse	42	68	30
Lynn	44	86	13
Bridgeport	80	66	31
Philadelphia*	88*	31*	66*
Schenectady	32	63	23
Fort Wayne	43	73	19
Lockland	63	85	10

* Distributed only to those represented by Philadelphia's independent union, Association of Engineers and Engineering Assistants.

3. There was some misunderstanding concerning the status of groups in the organization. (Individual membership only is planned.)

CONCLUSIONS

1. We feel that the search for unity already has gone too long, and that if it fails to be achieved soon, it may very well never be realized. The time available for a solution is fast running out.

2. We suggest to readers in considering this plan that, bearing in mind the long series of attempts to achieve a Unity Organization, they consider the proposal broadly—and support it if it meets their basic requirements. It is very easy to deadlock over small details and "fail to see the forest for the trees." Our fine American Constitution never would have been born if our forebears had lost sight of their broad primary objective and failed to realize the spirit of co-operation and sacrifice which was essential to success. Can we somehow help history to repeat itself?

3. We believe that this is the first time that the individual members of a large group of engineers have been polled and invited to comment on any unity plan. In view of the widespread interest in a Unity Organization, the failure of the Exploratory Group's proposal to obtain acceptance, and the widespread support shown for this proposal in the poll of General Electric engineers (including about 600 comments), we feel that this plan offers an excellent opportunity finally to achieve unity.

4. We hope that AIEE, NSPE, and other engineering societies will find some value in this plan and support it or one similar to it. We particularly hope that you—the individual reader—will decide you would support a plan of this type and LET YOUR SUPPORT BE KNOWN. THE TIME FOR ACTION IS NOW!

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† Definition of a "professional engineer" (extract from Salary Stabilization Board Interpretation 12, July 1, 1952):

(*a*). A professional engineer is a person who, by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience, is qualified to apply such special knowledge for the purpose of rendering professional services or accomplishing creative work, such as consultation, investigation, evaluation, planning, design, or supervision of construction for the purpose of assuring compliance with specifications and design in connection with structures, machines, processes, works, or projects.

(*b*). A person is qualified as a professional engineer by reason of his professional education, if he holds a professional engineering degree from a college, university, or institute of technology, authorized under the laws of the jurisdiction in which it is located to grant academic degrees in professional engineering.

(*c*). A person licensed or registered to practice as a professional engineer in any state, territory, or possession of the United States or in the District of Columbia is qualified as a professional engineer.

** This survey questionnaire described the original plan.

Trends in Rapid-Transit Car Design

COL. S. H. BINGHAM, AUS (RET.)

After pointing out that railroads should handle their commuter business on a rapid-transit basis, the ideal transit car is described. The qualifications are maximum safety, low initial cost, low operating and maintenance costs, operating characteristics allowing easy and economical maintenance of high schedule speeds, attractiveness, and comfort for the passengers. Suggestions are made about conditions requiring the electrical engineer's special attention.

STARTING WITH certain premises about car requirements for rapid-transit operation, criteria can be developed for car design, construction, and maintenance, and a mental picture of the ideal car can be drawn. Much progress has been made in rail-car construction, but this theoretical approach will show the distance still to go before it can be said this car meets all needs.

While this article is mainly concerned with rapid-transit cars, the same considerations apply to all rail passenger cars and particularly commuter cars. One of the greatest mistakes the railroads make is in failing to handle their commuter business on a rapid-transit basis, rather than as a stepchild of traditional main-line passenger service.

With the growth of suburban communities, and the increasing and apparently insoluble snarl of automobile traffic, greater attention will have to be paid to suburban rail services. There is a danger to the railroads in the abandonment of branch lines that apparently is not always considered. When the rail service is abandoned passengers are forced to use busses or private automobiles. This results in a demand for more and better roads. With improved roads and poorer rail service, the freight business soon follows the passengers.

How can the railroads hope to prosper by a continued process of surrendering bits of business to their competitors? With a private right-of-way giving them tremendous advantage over the vehicles on today's crowded highways, the railroads should work towards developing equipment that will permit them to compete economically.

What are the characteristics of the ideal rapid-transit car? First and foremost, the transit operating company requires maximum safety. Then it requires a car with a low initial cost, low operating and maintenance costs, and operating characteristics that permit easy and economical maintenance of high schedule speeds. All of this must be accomplished in a car that is attractive in appearance and comfortable for the passenger. This is not a small order.

It is not possible to speak with absolute certainty about the passengers' wants. For like all such abstractions, it is impossible to corner the average passenger to discuss this problem with him. However, quite definite ideas of the desires of some passengers are known from the letters they have written to the New York City Board of Transportation, the newspapers, and their elected officials. Ideas also come from their remarks to train crews and other employees coming directly in contact with the riders. The reactions of people in the industry who are passengers as well as employees are also available.

From this information it can be said that the passenger's ideal car would not differ radically from the operator's ideal. The passenger also wants a safe, fast, comfortable, and attractive car. He might go still further in looking for comforts such as air conditioning. Of course there is no basic reason to expect the operator's criteria to differ widely from the passenger's. You will agree that unless the operator pleases his passengers he will not need many cars.

The prime consideration of everybody concerned in car design must be safety. The braking system must be as foolproof and efficient as possible and must include automatic devices to apply the brakes in case of failure of men or equipment. Interlocking devices that prevent application of power until specific conditions are complied with are also essential. Much progress has been made in achieving this aim, with dynamic and air brakes, the dead-man's button, door interlocks, and similar equipment. The cars of the New York City Transit System incorporate every known feature to achieve maximum safety.

One conceivable line for future improvement in safety and increasing rail capacity lies in a field not primarily that of the car builder, although he would have to participate in the development and installation of the equipment. This would be a signal and train control system actuated not by track circuits in signal blocks, but one depending on the distance between two trains and their speeds. There are electronic devices capable of transmitting such information between points. Their adaptation to train service and the design of the necessary car equipment requires much development, but this is a possible line of inquiry.

Obviously the car must have sufficient impact strength to resist normal shocks in service and provide a margin of safety in case of serious accident. However, the controversy between the light and heavy car advocates will not be discussed here.

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953, and recommended for publication by the AIEE Committee on Land Transportation.

S. H. Bingham is Chairman of the Board of Transportation, New York, N. Y.

The interior of the car, the seats, and all the fittings should be designed to minimize accident hazards. There should be a sufficient number of stanchions and hand-holds to permit passengers to stand or move through the car with ease and safety when the train is in motion.

There is not much point in laboring safety requirements. They are so much in the forefront of the mind of each builder and operator that tremendous progress has been made in this field and undoubtedly will continue.

The next major objective in designing an ideal car is low initial cost. Here of course there is a possible contradiction between low first cost and low operating and maintenance costs. Each item of car equipment must be carefully studied, keeping both factors in mind, and from the nature of the problem the solution is apt to be a compromise. Like all compromises this one must be constantly restudied as conditions change and as new materials and techniques develop.

As one item of low first cost, the New York City Transit System has been a strong advocate of the large car. This may sound like a paradox since a large car costs more than a small one. There are two reasons for favoring large cars. First they are more economical in New York. Fewer cars are needed to provide the required service capacity. The total fleet cost is probably no greater than if there were a greater number of smaller cars. Furthermore, train manpower costs depend on the number of cars per train. With large cars more passengers are carried at the same manpower cost than with small cars. Secondly, with the tremendous passenger load the needed capacity could not be provided with smaller cars without building additional subways.

New York is unlike any other city in the world in its transit characteristics. Its rapid-transit lines now carry 5,250,000 passengers on an average weekday. In a year the total number of rapid-transit passengers carried is over 1,500,000,000, equivalent to ten rides per year for every resident of the United States.

If this passenger load were evenly distributed throughout the week the need for a large car might not be so urgent. As it is, about half the traffic on the transit lines is concentrated into two rush periods each working day covering approximately 4 hours per day 5 days per week. During the maximum traffic hour, 5 to 6 p.m. on a weekday, more than 800,000 passengers enter the rapid-transit stations, mainly in the congested downtown areas. In order to carry these people under such conditions, cars must be large. The new lines are therefore designed for cars 60 feet long and 10 feet wide with a maximum rated capacity of 300 passengers.

Unfortunately during rush hours any design capacity becomes more than merely a theoretical engineering standard, as you can readily observe by visiting Grand Central Station on the Lexington Avenue Line at 5:20 p.m. any weekday.

Two possible ways of reducing the initial cost of cars are to some extent beyond the control of the manufacturer. One is in standardization of new cars and components. Standardization of cars is undoubtedly difficult. Service requirements on different properties dictate differences in specifications. There is a suspicion that many of these differences arise in some part from tradition and personal idiosyncracies. It seems certain that there are large advances possible in standardization of many components. As long as cars remain essentially custom tailored the benefits of large-scale production are unattainable.

Photographs courtesy Pullman Standard Car Manufacturing Company

Figure 1. Exterior view of proposed passenger car

Figure 2. Interior view of proposed passenger car with walls and trim of stainless steel and aluminum

The other factor in high initial cost is the sporadic way in which orders for cars are placed. Car builders state that if firm orders could be placed for a specified number of cars each year for a period of 5 or more years they could establish production lines and fabricate these cars at a considerable reduction in cost. The New York City Board of Transportation is anxious to set up such a program. However, its capital funds come from the city budget and unfortunately the Board of Transportation cannot commit the city fathers to any such program. Experience with the purchase of new cars has been one of alternating periods of feast and famine. In the immediate postwar years 760 cars were purchased. Since the 1947 budget, the capital funds have not been available to establish such

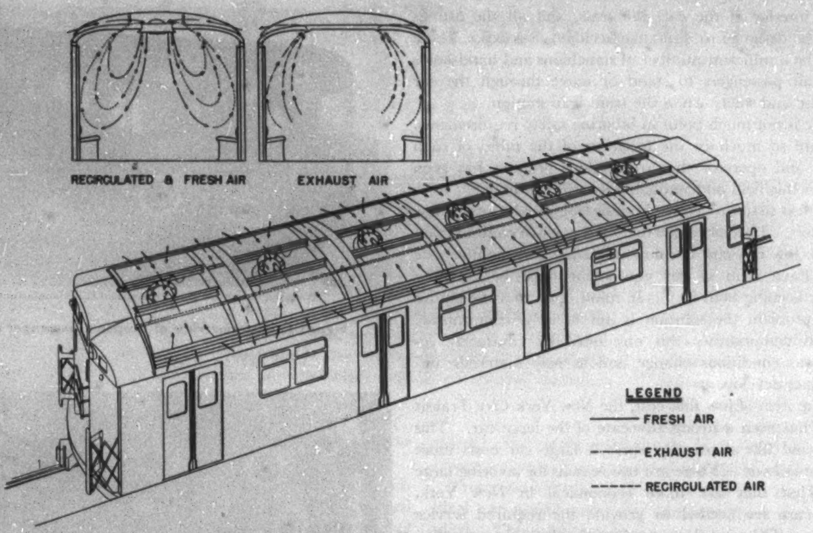

Figure 3. Air-circulating system in proposed passenger car. Fresh air enters and is circulated together with the recirculated air by fan, as shown upper left, and exhaust air flows out, see upper right

a program, even though many replacements for overage cars are needed.

The third major objective in the quest for the ideal car is to achieve low operating costs. Here there has been very substantial progress. With multiple-unit operation in New York City, now an 8-car train operates with a capacity of about 2,000 passengers and a crew of one motorman and one conductor. When trains are lengthened to ten cars another conductor is added. It will be quite difficult to cut these personnel requirements unless a completely automatic railroad is resorted to. With modern developments in electronic devices, an automatic railroad will be technologically possible in the not too distant future. The major obstacle then will be the psychological reaction of the passengers.

With the new and efficient motors, package controls, and dynamic braking, the maximum scheduled speed possible with local stations less than half a mile apart, as on the New York City Transit System Lines, is being approached. There is undoubtedly room for improvement in motors, controls, braking equipment and the like, but these probably will lie in the direction of greater efficiency and lower cost rather than greatly increased maximum speeds. The latest New York City cars accelerate at $2^1/_2$ miles per hour per second and brake up to 4 miles per hour per second. With these rates the average scheduled speed is 20 miles per hour for express trains and 16 to 18 miles per hour for locals. This is the best that can be done with equipment designed with balancing speeds of 40 to 50 miles per hour. Any increase in these rates will increase costs substantially, and will approach the limits of passenger comfort.

The next important area for study of the ideal car lies in the direction of reducing maintenance costs. Here there are opportunities for great progress. The electrical engineers should not become too complacent about this, but it is felt that more progress has been made in the design of motors and electric control equipment than in many features of body design.

Increasing life of equipment by using noncorrosive materials requiring no painting is one approach. The stainless-steel car was a long step ahead in this direction. New York City has one train of ten stainless-steel cars, but there are not yet sufficient data to compare the increased cost of this equipment with possible savings in maintenance costs.

The design of car equipment components for long operating intervals between inspection and servicing periods is another way of reducing maintenance costs. Of almost equal importance is design and installation so that access to parts is easy, and removal and installation can be accomplished simply and rapidly.

Advances have been made in reducing servicing costs. On the new cars, there are items of equipment such as motor and door controls and brake components which now are serviced every 5,000 instead of every 2,000 miles.

Dynamic braking has multiplied brake-shoe life fivefold and data so far accumulated indicate a doubling of wheel life. But there is still much room for progress, and with labor costs constantly increasing, important savings in costs can be realized from such improvements.

Cleaning still remains a major problem. Some of the car builders would do well to employ an industrial designer to go over proposed car interiors and eliminate all the corners, fittings, and projecting points and studs of all kinds that serve merely as places to collect dust. There are many new finishing materials available that require no paint and to which dirt and dust do not readily adhere. These should be used instead of the traditional sheet metal, with a short-lived coat of paint. See Figures 1 and 2. Manufacturers of brakes and controls, for example, also could help by designing their equipment to keep dirt out and to make cleaning easier.

In the newest cars in the New York City Transit System fluorescent lights have been installed to make the car brighter and more cheerful, and enable the passenger to read his paper without eyestrain. Despite improvements made in the last 4 years, these fluorescent lights still cost more than incandescent lights to install and maintain. It is felt that the contribution they make to passenger comfort is worth the additional cost, but lighting engineers should try to reduce these costs. Whether this is done by improving the existing lamps, or going to lamps operating at high frequencies, with a special alternator for the lamp circuit, is a question left to the engineers.

Heating, cooling, and ventilating cars is probably where the greatest contributions to passenger comfort are possible. The latest cars, with automatic heat and fan control, are a great improvement. They provide for continuous thermostatic control of fans over their entire speed range in hot weather, and heat control combined with slow rotation of the fans for some circulation in cold weather. Much still remains to be done to improve this system, particularly to control the ratio of outside to recirculated air. See Figure 3.

Most of the complaints about cold cars are really complaints about passengers' cold feet. A heated floor would eliminate this source of complaint and increase passenger comfort. Present monolithic car floors are not entirely satisfactory. The development of a flexible car flooring material with the wearing characteristics of existing flooring, and with some provision for heating by electricity, would be a boon to both the operator and the passenger. Radiant heating for car floors has been considered in the past. Would new developments in materials not make reconsideration worth while now?

Another attack on the car-heating problem has been made by designing some experimental cars heated by blowing air over the motor resistors and distributing it through the car by a duct and blower system. None of these has been very satisfactory yet. Presidents' Conference Committee cars were perhaps the most successful examples. Application to rapid-transit cars is more difficult because of the amount of equipment and the difficulty and cost of achieving a satisfactory duct distribution system.

The one big thing that passengers ask for when queried about increased comfort in rapid-transit cars is air conditioning. Experienced engineers have said that under the subway operating conditions in New York, effective air conditioning might require the use of one-half of the cars on a train for the air-conditioning equipment needed to cool the remaining cars. This is another problem for engineers to solve.

Only some of the high spots of a tremendous subject have been brought out here. Some of these problems are perhaps outside the primary interests of the electrical engineer. However, the rapid-transit car of today is the result of studies and improvements made by generations of engineers in all specialties, and the better cars of the future will come from similar studies and tests by engineers.

Jet Autopilot Locates Target, Fires, Goes Home

Development of an automatic pilot to guide jet fighters to their targets with electronic precision has been announced by the Aeronautical Division of Minneapolis-Honeywell Regulator Company. The new pilot is designed to make automatic the whole procedure of flying a fighter plane, finding and attacking the target, and homing the airplane.

Automatic attack, the most recent addition to push-button warfare in the air, is accomplished by hooking up a radar and fire-control system with the autopilot. The radar sees the target, the autopilot directs the airplane to the target, and the guns fire automatically when in effective range.

The company announced that it already has received orders to install the new autopilot on the Air Force's latest twin-jet light bomber, the Douglas *RB-66*.

"Our newest jet planes," said Robert Kutzler, chief engineer, flight control section, "are reaching the point of speed and complexity where a pilot can no longer manage them unassisted for any length of time without suffering fatigue. Targets appear and disappear so suddenly he must have a means of engaging them and knocking them out literally before he sees them" the engineer declared.

He pointed out that when two opposing airplanes approach each other at 700 miles an hour, amounting to a closing speed of 1,400 miles an hour, only 2 seconds elapse from the time the pilots see each other and the instant they are in effective firing range.

The autopilot, when tied in with a radar–fire-control hook-up, will be able to direct the plane accurately to its target in such situations long before the human pilot even sees it.

Even though the human pilot can make the robot copilot do his bidding at all times, the robot will not permit maneuvers that might endanger the plane. The autopilot adjusts itself instantly to a different feel of the controls at rapidly changing jet speeds.

The autopilot makes night and bad weather operations safer and more assured of success, and it frees the pilot of any guesswork in navigation. Features such as an altitude controller that maintains flight at a chosen height, a compass coupler that puts the autopilot on a selected compass heading, and an instrument landing tie-in make the pilot's job safer.

INSTITUTE ACTIVITIES

Appliance Technical Conference to Be Held During AIEE Southern District Meeting

The AIEE Southern District Meeting and Student Branch Meeting will be held concurrently this year at Louisville, Ky., Wednesday, Thursday, and Friday, April 22–24. The AIEE Committee on Domestic and Commercial Applications of the General Applications Division will hold their Appliance Conference during this meeting. The opening general meeting for all is scheduled for Wednesday at 10:00 a.m.

Headquarters for the Southern District Meeting will be at the Hotel Seelbach located in the heart of downtown Louisville. Excellent facilities are awaiting members and guests attending this meeting; all meeting rooms and many of the guest rooms are air conditioned and the hotel coffee shop is open around the clock.

Other hotels that will be used for housing are in easy walking distance of Headquarters. Arrangements have been made to accommodate students in dormitory-type rooms at the Seelbach. The ladies will be interested to know that Louisville's best stores and dress shops are within a few steps of the hotel. The Belknot Campus of the University of Louisville is within 15 minutes walk of the hotel and several of the student meetings will be held on the campus at the Speed Scientific School, the Engineering College of the university.

SPORTS

Churchill Downs, home of the Kentucky Derby, is a few minutes from the Louisville Campus. The Spring Racing Meet will start on April 25, the day after the Southern District Meeting. Recreation and sports facilities in Louisville include city parks for the family, tennis courts (both public and private), municipal yacht harbor, two airports, and downtown movies. Golfing privileges are available to all who wish to play. There are several private and municipal courses from which to select.

INSPECTION TRIPS

Many interesting inspection trips have been arranged as follows, for those members and guests attending the Southern District Meeting:

1. American Air Filter Corporation, a large manufacturer of air filters of both the mechanical and electrostatic type.
2. American Radiator and Standard Sanitary Corporation, manufacturers of bathroom fixtures.
3. Colgate-Palmolive-Peet Company, manufacturers of soaps, powders, and creams.
4. *Courier-Journal* and *Times* with its own television channel, *WHAS*, in the heart of Louisville, near the convention hotel. Here visitors will see the news printed and telecasted at the same time.
5. The Louisville Gas and Electric Company, with both hydro- and steam-electric plants.
6. The Mengel Corporation, one of the largest furniture manufacturers in the United States. Modern equipment includes high-frequency gluing machines.
7. Phillip Morris' newest and only plant making king-size cigarettes.
8. Joseph E. Seagram and Sons, Inc., have one of several distilleries in this vicinity.
9. The International Harvester Company, manufacturers of farm machinery. This trip will feature a large induction-heating machine for case hardening gears.
10. The Girdler Corporation, manu-

Louisville skyline from the Indiana side of the Ohio River; at the left is the George Rogers Clark Memorial Bridge connecting Kentucky and Indiana

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Future AIEE Meetings

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 20–21, 1953

Southern District Meeting
Seelbach Hotel, Louisville, Ky.
April 22–24, 1953
including
Conference on Domestic Appliances
Louisville, Ky.
April 22–24, 1953

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 23–24, 1953

North Eastern District Meeting
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
including
Northern Textile Conference
Sheraton Plaza Hotel, Boston, Mass.
May 1, 1953

AIEE-IRE-RTMA-WCEMA West Coast Electronics Conference
Shakespear Club, Pasadena, Calif.
April 29–May 1, 1953

AIEE-IRE-ISA-IAS Telemetering Conference
Edgewater Beach Hotel, Chicago, Ill.
May 20–22, 1953

Conference on Electric Heating
Detroit-Leland Hotel, Detroit, Mich.
May 26–27, 1953

Summer General Meeting
Chalfonte-Haddon Hall Hotel, Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—closed*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 3*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Conference on Machine Tools
Cleveland, Ohio
October 14–16, 1953

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

facturers of dielectric heating equipment which has become a new tool in industrial plants during the past several years.

11. The Gunnison Housing Corporation, one of the largest manufacturers of prefabricated houses.

12. General Electric's new plant, designated Appliance Park, which is now ready to receive visitors.

Times and dates of these inspection trips will be posted at the meeting.

SOCIAL PROGRAM

Sightseeing tours have been planned through Churchill Downs, the historical Cave Hill Cemetery, the large city parks, the Ohio River front, the University of Louisville, and the shopping centers of the city; an all-day trip to Mammoth Cave has also been arranged.

On Wednesday evening entertainment and a social hour have been scheduled for all as guests of the District. On Thursday evening there will be a banquet and dance. A luncheon for the student counselors is scheduled for Thursday noon.

The ladies will have an opportunity to enjoy the lovely spring season in Kentucky at Louisville, which is famous for its large and beautiful parks, hills covered with beautiful residences, and points of historical interest.

On Wednesday morning the ladies will be started on a tour with lunch at The Old House. From there they will tour *WHAS-TV* to see a live telecast and radio program. The evening is reserved for the general reception at the headquarters hotel.

Thursday will feature a tour of the city, starting at 9:30 a.m. with the river front and the only inland Coast Guard station in the United States, thence to the University of Louisville, Iroquois Park, and the out-of-doors Amphitheatre, where light opera and the popular current shows are put on by summer stock companies. A conducted tour of the famous Churchill Downs race track with lunch in the clubhouse follows with a drive through Cherokee and Seneca Parks, a stop at Garden Court, the university's school of music, and a trip to the Southern Baptist Seminary, the largest Baptist seminary in the world. From there a trip through the American Printing House for the Blind, also largest of its kind, will show how Braille books are printed, records are cut and pressed, and so forth. The evening is reserved for the dinner-dance.

Friday will bring a trip through Mary Alice Hadley's Pottery, and shopping and tea at Stewarts, Louisville's largest department store.

HOTEL RESERVATIONS

Those planning to attend this meeting should make hotel reservations as soon as possible. Special low-cost accommodations will be available for a limited number of students at the headquarters hotel. The room rates at the Seelbach Hotel (headquarters hotel) are as follows:

Single rooms	$ 4.75 to $12.00
Double rooms	7.25 to 15.00
Suites	20.00 to 25.00

COMMITTEE

Members of the Southern District Meeting Committee are M. G. Northrop, General Chairman; J. G. Lips, Vice-Chairman; J. D. Warren, Secretary; W. J. Ryan, Finance; J. F. Gregory, Registration; H. T. Smith, Hotels and Meeting Rooms; T. W. Talcott, Meetings and Equipment; J. D. Caudill, Entertainment; O. W. Towner, Publicity; R. D. Spaulding, Transportation; W. B. Watkins, Inspection Trips; S. T. Fife, Student Activities; J. M. Houchens, Printing; L. G. Weiser, Sports; and T. T. Woodson, Appliance Technical Conference.

Tentative Technical Program

Southern District Meeting, Louisville, Ky., April 22–24

Tuesday, April 21

5 to 9 p.m. Registration

Wednesday, April 22

8:00 a.m. Registration

10:00 a.m. General Meeting

Welcome by Mayor Charles Farnsley

Address by AIEE President Donald Quarles

12:15 p.m. Luncheon

Address by Former Governor Keen Johnson

2:00 p.m. Industry

DP. Relay Co-ordination in Industrial Plants.** *F. P. Brightman*, General Electric Company

DP. A Variable-Frequency Drive for Synthetic Fiber Spinning Machines.** *H. L. Stiltz*, E. I. du Pont de Nemours & Co.

DP. Magamp-Controlled Winder Drive.** *Robert Posey*, Westinghouse Electric Corporation

53-179. Power Equalizer Systems for Aircraft Alternators. *J. A. Granath*, *A. K. Hawkes*, Armour Research Foundation of Illinois Institute of Technology

DP. The Determination of Rotor Inductance and Resistance for Drag-Cup Servomotor.** *W. A. Stein*, United States Naval Postgraduate School

53-180. Multitransformer Welding Presses. *J. Ogden*, General Motors Corporation

2:00 p.m. Power

DP. Fan Cooling of Transformers and Their Economics.** *Charles Jaeger*, Alabama Power Company

DP. Measuring and Recording Small Voltage Variations Produced by Variable Loads.** *R. W. Baker*, Georgia Power Company

DP. Design of a Dispatching Office.** *W. J. Wortman*, *H. E. Redding*, Duke Power Company

DP. Slope Correction Factors for Calculating Short-Circuit Forces of Busses Composed of Double-Channel Conductors.** *T. J. Higgins*, University of Wisconsin; *C. M. Siegel*, University of Virginia

DP. Restraining the Repulsive Forces in Large Duplex Reactors.** *L. E. Sauer*, Westinghouse Electric Corporation

2:00 p.m. Students

6:30 p.m. Reception and Entertainment

Thursday, April 23

8:00 a.m. Registration

9:00 a.m. Communications and Electronics

DP. A Discussion on Methods of Measuring Space Charge.** *William Dodson*, American Air Filter Company

DP. A Semiempirical Equation of Electrostatic Precipitation.** *E. A. Walker*, Pennsylvania State College; *J. E. Coolidge*, Borg-Warner Central Research Laboratory

DP. Dielectric Heating Design Problems.** *T. L. Wilson*, The Girdler Corporation

DP. Rigorous Calculation of the Capacitance and Characteristic Impedance of Coaxial Transmission Lines Composed of Rectangular Tubular Conductors.** *T. J. Higgins*, *Shizuo Hori*, University of Wisconsin

DP. An Electronic Multiplier.** *E. L. Peterson*, Tulane University

DP. The Influence of Capacitance Variation Upon the Performance of the Self-Saturating Magnetic Amplifier.** *Yun Chang*, Cincinnati, Ohio

9:00 a.m. Power

53-181. Skin and Spiraling Effect in Stranded Conductors. *John Zaborszky*, University of Missouri

DP. Operating Experience With Connectors for Aluminum Conductors.** *C. E. Bryan*, Jackson Electric Company

53-182. A Direct Method for Sag-Tension Calculations. *T. P. Harley*, Bureau of Reclamation

53-183. The Duty on Expulsion-Type Lightning Arresters for Distribution Systems. *Otto Ackermann*, Westinghouse Electric Corporation

DP. Progress in Current Transformer Designs.** *F. J. Vogel*, *D. R. Laib*, Allis-Chalmers Manufacturing Company

9:00 a.m. Students

9:00 a.m. Inspection Trips

12:15 p.m. Luncheon

2:00 p.m. Industry

53-185. Alternating Versus Direct Current for Underground Mining. *J. Z. Linsenmeyer*, *A. G. Owen*, Westinghouse Electric Corporation

DP. Some Considerations Concerning Electrical Hazards in Coal Mining.** *G. C. Barnes, Jr.*, Virginia Polytechnical Institute

DP. Technical Aspects of Electric Equipment Applications in Coal-Preparation Plants.** *W. R. Morton*, General Electric Company

DP. Outdoor Motor Enclosures.** *W. S. Hines*, Westinghouse Electric Corporation

DP. Grounding of Industrial Power Systems.** *L. J. Carpenter*, General Electric Company

53-186. A Mechanism for the Fuse Prearcing Period. *E. B. Carne*, Remington Rand Inc.

2:00 p.m. General Group

DP. The Arnold Engineering Development Center. Power System.** *D. J. Goodman*, Electrical Branch, Technical Services Division ARO, Inc.

DP. Electric Equipment in the Arnold Engineering Development Center Test Facilities.** *F. P. Sener*, Lieutenant, United States Air Force, Arnold Engineering Development Center.

DP. Electric Power, a Creative Force in North Carolina.** *G. Brennecke*, North Carolina State College

DP. Educational Training for Living.** *Claudius Lee*, Virginia Polytechnical Institute

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* **ACO**: Advance copies only available; not intended for publication in *Transactions*.

** **DP**: District paper; no advance copies are available; not intended for publication in *Transactions*.

DP. New Features Incorporated in the New Electrical Engineering Laboratories at the University of South Carolina,** (illustrated with slides). *J. H. Noland, Jr.*, University of South Carolina

2:00 p.m. Communications and Electronics

53-187. Communications for Civil Defense. *C. A. Armstrong*, American Telephone and Telegraph Company (1$^1/_2$-hour program, illustrated)

2:00 p.m. Inspection Trips

7:00 p.m. Dinner

Student Awards presentation

9:00 p.m. Dance

Friday, April 24

9:00 a.m. Power

DP. Cathodic Control of Corrosion.** *W. T. Zumwalt*, Tennessee Valley Authority

DP. A Simplified Method of Field Testing Network Protectors.** *J. H. Miller, Jr.*, Alabama Power Company

53-188. Back-up Protection for Generators. *E. T. B. Gross*, Illinois Institute of Technology; *L. B. LeVesconte*, Sargent and Lundy

53-189–ACO.* Economical Loading of Transformers. *W. M. Hanna*, Consolidated Gas, Electric Light and Power Company

DP. Application of Narrow-Band Frequency-Shift Equipment for Power-Line Carrier.** *D. C. Abbott*, Westinghouse Electric Corporation

53-190–ACO.* Multistation Supervisory Control Over Single-Frequency Carrier. *E. W. Miller, W. M. Larson*, Control Corporation; *J. G. Wright*, Kansas Power and Light Company

9:00 a.m. Communications and Electronics

DP. Design Criteria for Tube Aging and Tube Testing Oak Ridge National Laboratory.** *G. A. Holt*, Oak Ridge National Laboratory

DP. Radio Telephone From Wilmington to Shallottee, N. C.** *W. C. Burnett*, Southern Bell Telephone Company

53-191. Path Testing for Microwave Radio Routes. *R. D. Campbell*, American Telephone and Telegraph Company

53-192. Computation of Impedance and Efficiency of Transmission Line With High Standing-Wave Ratio. *W. W. Macalpine*, Federal Telecommunication Laboratory

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—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Operations Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

53-193. A Capacitively Coupled Field Mapper for 2-Dimensional Distributed Source Field Problems. *E. O.* and *E. G. Gilbert*, Ann Arbor, Mich.

9:00 a.m. Student Business Meeting

9:00 a.m. Inspection Trips

2:00 p.m. Inspection Trips

Appliance Technical Conference

Theme: Appliance Control Components (II)

April 22

Wednesday a.m. General Meeting

Wednesday p.m. Technical Session

New Heat Control. General Electric Company, Morrison, Ill.

Appliance Control. Frigidaire Division, Dayton, Ohio

Reversed Bimetal. Spencer Thermostat Division, Attleboro, Mass.

Quality Testing. Cutler Hammer, Inc., Milwaukee, Wis.

April 23

Thursday a.m. Technical Session

Kitchen Layout Studies. Cornell University, Ithaca N. Y.

Functional Design. General Electric Company, Louisville, Ky.

Control Requirements. Whirlpool Corporation, St. Joseph, Mich.

Dishwasher Controls. General Electric Company, Louisville, Ky.

Grounding Plugs. General Electric Company, Bridgeport, Conn.

Thursday p.m. Special Tour of General Electric's New Appliance Park

April 24

Friday a.m. Symposium on Overcurrent Protection for Appliances

Participants:

W. H. Farrell, Underwriters Laboratory, Chicago, Ill.

F. G. VonHoorn, General Electric Company, Bridgeport, Conn.

E.P. Jastram, Spencer Thermostat Company, Attleboro, Mass.

J. C. Lebens, Bussman Manufacturing Company, St. Louis, Mo.

Arthur Steele, Littlefuse Manufacturing Company, Des Plaines, Ill.

G. W. Heumann, General Electric Company, Schenectady, N. Y.

Friday p.m. Inspection Trips

North Eastern District Meeting Program to Include Northern Textile Conference

The AIEE Boston Section, host to the 1953 North Eastern District Meeting, April 29–May 1, this year celebrates its 50th anniversary—in company with the Philadelphia and Schenectady Sections. Thus, an especially interesting meeting program has been planned, with the golden anniversary as its theme. In addition, Boston itself and its environs offer many points of historical interest which should not be missed.

The General Meeting, to be held Thursday morning, April 30, in the Ballroom of the Sheraton Plaza, the headquarters hotel, will celebrate the 100th anniversary of the birth of Dr. Elihu Thompson, a founder of the Boston Section. Two excellent and well-known speakers will address this meeting: Dr. Karl T. Compton of the Massachusetts Institute of Technology, and Dr. Lawrence R. Hafstad of the United States Atomic Energy Commission.

NORTHERN TEXTILE CONFERENCE

The North Eastern District Meeting has been selected by the AIEE Textile Industry Subcommittee for their annual Northern Textile Conference. This selection is deemed particularly appropriate because of the central location of Boston and the large number of textile manufacturers in this area. All members and guests may attend these sessions (see page 361).

INSPECTION TRIPS

Simplex Wire and Cable, Cambridge, Mass. (Wednesday afternoon, April 29). This company manufactures nearly all types of electrically insulated wire and cable. The Cambridge organization consists of the factory, general offices, and laboratories, and those making the trip will have an opportunity to see all the major processes involved in manufacture. These include stranding of conductors; mixing rubber compounds; insulating wire with rubber, paper, varnished cambric, and plastics; cabling of multiconductor cables; and application of outer coverings such as lead sheath, rubber jacket, wire armor, and weatherproof braids. The group also will visit the laboratories and will see a high-voltage demonstration.

Massachusetts Institute of Technology, Cambridge, Mass. (Thursday afternoon, April 30). This world-renowned institution is located on the banks of the Charles River facing Boston proper. The trip will include stops at the Cyclotron, Synchrotron, Linear Accelerator, and the Research Laboratory of Electronics comprising communications, frequency modulation, television, and computers. This trip will be limited, of necessity, to the first 48 persons signing up.

Museum of Science, Science Park, Boston, Mass. (Thursday afternoon, April 30). Of

Air view of Boston, with the Charles River in the background

special interest to AIEE visitors will be exhibits of Professor Elihu Thompson's inventions, commemorating the 100th anniversary of his birth. Dr. Thompson was one of the pioneers in the electrical industry and a founder of the Boston Section. Other items of interest at Science Park include a working dial-telephone system, a continuous cloud chamber giving visible evidence of the existence of atomic particles, a Sand-Pattern Pendulum which makes Lissajous figures, and a detailed diorama showing how the Egyptians may have constructed their great pyramids.

Hytron Radio and Electronics Company, Danvers, Mass. (Friday morning, May 1). This is one of the most modern electronic tube plants in the world and is a division of Columbia Broadcasting System, Inc. Its four plants employ 5,500 persons and produce millions of tubes a month. Equipment used in manufacture is so modern that it could not be purchased, but was designed in a special machine shop purchased by Hytron. Layout of the plant is functional, modern, and uses five kinds of gases and three kinds of electric power, for which a special tunnel system honeycombs the basement. A special Development Tube Shop is equipped exactly the same as a production unit in the factory proper and is used solely for engineering purposes.

Salem Harbor Plant, New England Power Company, Salem, Mass. (Friday morning, May 1). Construction was started in December 1948 and the first of two 75,000-kw turbine generators went into commercial operation on January 1, 1952. The combined units will have a yearly output of more than 1,000,000,000 kilowatt-hours. The plant serves a large portion of the North Shore District of Boston. Built on solid rock, the total initial cost for the 2-unit plant was over $30,000,000.

LADIES' ACTIVITIES

Mrs. L. J. Weed and her committee have planned an excellent program of activities for the ladies attending the meeting. Parlor 131 at the Sheraton Plaza has been reserved as a Ladies' Headquarters and will be staffed at all times during the meeting to aid in planning activities and for general information.

A Get-Acquainted Tea will be held at the Ladies' Headquarters at 3 p.m. on Wednesday, April 29. At 6:30 of the same day, a cocktail hour and dinner party will be held at the University Club. Entertainment will be provided by Sherwood Blodgett, Magician. He has performed at numerous Boston functions and should have an interesting program.

For Thursday morning, April 30, a sightseeing tour has been planned which will include stops at the Christian Science Mapparium, the home of Longfellow, Agassiz Museum—home of the glass flowers, Harvard University, and the home of James Russell Lowell.

Luncheon on Thursday will be at a restaurant in Chinatown, after which the group will visit the Chinese Merchants Association, largest of its kind in the United States, which contains rooms of embroidered paintings and a pagoda.

At 3 p.m. a demonstration of oil paintings will be given by the New England artist, James King Bonnar. Mr. Bonnar will illustrate the technique he employs in this medium and upon completion of the painting, will answer questions. Also at 3 p.m., a joint inspection trip will be held at the Museum of Science.

On Thursday evening the ladies are invited to join the men at the banquet, and on Friday morning the coffee hour at 10 a.m. will feature a talk on "The Secrets of the Powers' Girls" by a member of the John Robert Powers School. The afternoon will be free for shopping.

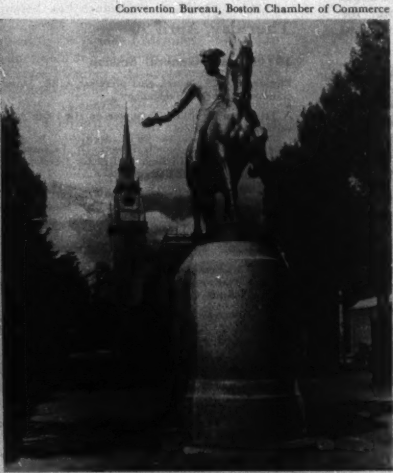
ENTERTAINMENT

On Wednesday evening, April 29, a smoker will be held at the Sheraton Plaza Hotel. Preceded by a cocktail hour at the Copley Club, a beef dinner for the men will be served in the Oval Room and State Suites. An hour of entertainment will follow supper.

The ballroom and foyer of the Sheraton Plaza will be the scenes for the Thursday evening banquet and dance. Lieutenant-Governor Sumner B. Whittier will be guest speaker at the banquet. The ladies are invited to attend and there will be dancing to Baron Hugo's music in the ballroom following dinner.

Tables will be arranged for the smoker and banquet in groups of ten. Reservations may be obtained from W. A. Carlson,

Convention Bureau, Boston Chamber of Commerce



Paul Revere Mall in Boston, with Revere statue. In background can be seen the Old North Church, the oldest church edifice in Boston (built in 1723), where Paul Revere received the signal that prompted his famous ride

Westinghouse Electric Corporation, 10 High Street, Boston, Mass.

REGISTRATION

Advance registration is requested by returning the advance registration card properly filled out. This procedure will save time in completing registration details upon arrival at the hotel. The registration fee payable at the meeting will be $2.00 for members, and $3.00 for nonmembers. No fee will be required of enrolled students and immediate families of members.

HOTEL RESERVATIONS

Members planning to attend the North Eastern District Meeting are urged to make hotel reservations now to be sure of accommodations. Blocks of rooms have been established at the Sheraton Plaza Hotel (meeting headquarters) and at the Hotels Statler and Lenox, both within 3 blocks of the Sheraton Plaza. Requests for reservations should be sent prior to April 15 to the hotel of choice, and to only one hotel, and attendance at the meeting mentioned. If the reserved block at the hotel of choice is filled, the Hotel Arrangements Committee will arrange for transfer to another.

Rates for rooms with bath are as follows:

Hotel Sheraton Plaza (headquarters), Copley Square	
Single room	$ 5.85 to $15.00
Double room, double bed	9.90 to 15.00
Double room, twin beds	11.00 to 16.00
Suite	25.00 to 35.00
Hotel Statler, Park Square	
Single room	$ 6.00 to $10.00
Double room, double bed	10.00 to 13.00
Double room, twin beds	12.00 to 16.50
Suite	25.00 to 29.50
Hotel Lenox, Boylston and Exeter Streets	
Single room	$ 5.00 to $ 6.00
Double room, double bed	7.00 to 8.00
Double room, twin beds	9.00 to 10.00
Suite	11.00 to 16.00

COMMITTEES

Members of the General Advisory Committee for the North Eastern District Meeting are as follows:

F. B. Haeussler, General Chairman; W. S. Hill, Vice-Chairman; G. J. Crowdes, Secretary; C. L. Devoe, Treasurer; L. F. Cleveland, Historian; C. A. Powel, Counselor; C. T. Abbott, C. W. Maloney, S. M. Osthagen, H. P. Turner, E. W. Boehne, W. F. Potter, L. J. Weed

Chairmen of other committees making arrangements for the meeting are as follows:

E. W. Dillard, Budget and Finance; F. D. Snyder, Technical Program; A. L. O'Banion, Registration; J. C. Hitt, Hotel Arrangements; L. T. Jester, Publicity; R. G. Porter, Student Branch Activity; W. A. Carlson, 50th Anniversary Banquet and Smoker; J. F. Archibald, Inspection Trips and Transportation; Mrs. L. J. Weed, Mrs. G. J. Crowdes, Ladies' Entertainment; F. S. Bacon, Jr., Hospitality; J. J. Loustaunau, Social Hour

Tentative Technical Program

North Eastern District Meeting, Boston, Mass., April 29–May 1

Tuesday, April 28

Registration Desk open in afternoon

Wednesday, April 29

8:30 a.m. Registration

9:30 a.m. Relaying

DP.* Comparison of Microwave Versus Carrier Channels for Protective Relaying. *H. W. Lensner*, Westinghouse Electric Corporation

DP.* A Simple Relay Scheme for Unit Generator-Transformer Station. *G. Steeb*, Niagara Mohawk Power Corporation

53-178. A Negative-Phase-Sequence Overcurrent Relay for Generator Protection. *W. C. Morris, L. E. Goff*, General Electric Company

9:30 a.m. Communication Transistors

Chairman: W. F. Potter

DP.* Basic Principles of Transistor Electronics. *M. Sparks*, Bell Telephone Laboratories, Inc.

DP.* Transistors as Circuit Elements. *R. L. Wallace, Jr.*, Bell Telephone Laboratories, Inc.

9:30 a.m. Voltage Regulation

DP.* Feeder Voltage Regulators. *E. Sagan*, Westinghouse Electric Corporation

DP.* Voltage Regulation by Phase-Angle Shift. *R. Wheatley*, Brockton Edison Company

DP.* Bus-Voltage Regulation. *D. R., Samson*, General Electric Company

12:00 noon. Luncheon. North Eastern District Executive Committee

2:30 p.m. Power System Communications

DP.* Automatic Load-Frequency Control Via Power-Line Carrier on New England Electric System. *L. G. Eaton, R. E. Minkwitz*, New England Power Service Company

DP.* Communication on the Central Maine Power Company's System. *A. Rogers, B. Payne*, Nepaco Services, Inc.

2:30 p.m. Magnetic Amplifiers

Chairman: Dr. T. S. Gray

DP.* Magnetic Amplifiers for Power Control. *Dr. E. L. Harder*, Westinghouse Electric Corporation

DP.* Magnetic Amplifier Circuit Techniques. *H. M. Ogle*, General Electric Company

DP.* Magnetic Amplifiers in Digital Computers. *D. A. Buck*, Massachusetts Institute of Technology

2:30 p.m. Industrial Power Distribution

Chairman: D. L. Beeman

DP.* Recent Progress in 480/277-Volt Systems in Office Buildings. *D. S. Brereton*, General Electric Company

DP.* Economic Modernization of Distribution Systems. *L. R. Valonen*, Westinghouse Electric Corporation

DP.* The New General Electric High-Capacity Switchgear Development Laboratory. *A. G. Boyd*, General Electric Company

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—THE PAPERS regularly approved by the Technical Operations Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

2:30 p.m. General Equipment Design

DP.* A Practical Method for Plotting Electrostatic Field Distribution and Equipotential Lines. *G. E. Jansson, William Harper*, Allis-Chalmers Manufacturing Company

DP.* Equations for the Inductance and Short-Circuit Forces of 3-Phase Busses Comprised of 120-Degree Angles. *J. W. Maier*, Bell Aircraft Company; *T. J. Higgins*, University of Wisconsin

DP.* Transformer Noise Problems. *K. P. Munter*, Allis-Chalmers Manufacturing Company

DP.* Distribution Transformer Capabilities. *J. B. Hodtum*, Allis-Chalmers Manufacturing Company

53-177. Report on Double-Cage Rotor Symposium. *J. J. Courtin*, Westinghouse Electric Corporation. Presentation by title only for discussion

6:30 p.m. Smoker

Social hour, Copley Club

Dinner, State Suite and Oval Room

Entertainment, Oval Room

Thursday, April 30

10:00 a.m. General Session

Presiding: C. A. Powel, past president AIEE, Massachusetts Institute of Technology

A Tribute to Dr. Elihu Thompson on His 100th Anniversary: C. A. Powel

Progress Report on Atomic Power: Dr. Lawrence R. Hafstad, Director, Division of Reactor Development, United States Atomic Energy Commission

Nuclear Research in Retrospect and Prospect: Dr. Karl T. Compton, Chairman of the Corporation, Massachusetts Institute of Technology

2:30 p.m. High-Voltage Transmission

DP.* Technical and Economic Aspects of High-Voltage Transmission-System Design. *L. E. Saline*, General Electric Company

DP.* Power-Line Crossings Over Water. *H. N. Furlong, L. O. Waite*, Stone and Webster Engineering Corporation

DP.* System Planning for Load Growth. *A. A. Johnson*, Westinghouse Electric Corporation

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*** DP:** District paper; no advance copies are available; not intended for publication in *Transactions*.

**** CP:** Conference paper; no advance copies are available; not intended for publication in *Transactions*.

2 : 30 p.m. Power Generation

DP.* Effects of Loss of Field in Synchronous Generators. *E. W. Church, F. Sherman*, Boston Edison Company

DP.* Excitation System for Turbine Generators. *D. B. Hoover*, Westinghouse Electric Corporation

2 :30 p.m. Productive Maintenance

DP.* The Key to Productive Maintenance. *H. F. McCullough*, General Electric Company

DP.* Preventive Maintenance in a Paper Mill. *N. L. Danforth*, St. Regis Paper Company

6 :30 p.m. Banquet

Guest: Lieutenant-Governor Sumner G. Whittier
Dancing: Baron Hugo and his orchestra

Friday, May 1

9 :30 a.m. Student Paper Sessions

(List of papers will be available at Registration Desk)

12 :30 p.m. Luncheon, Student Branch Chairmen and Counselors

2 :30 p.m. Industrial Process Control

Chairman: M. A. Princi

DP.* Selecting Parameters in Closed-Loop Process-Control Systems. *Dr. D. P. Campbell*, Massachusetts Institute of Technology

DP.* (Subject to be announced). *A. Holmes*, Monsanto Chemical Company

DP.* Electrical Instrumentation in Process Plant Control. *J. R. Ghublikian*, Badger Process Division, Stone and Webster Engineering Corporation

Northern Textile Conference

Friday, May 1

9 :30 a.m. Textile

Chairman: V. F. Sepavich

CP. Electric Equipment Built Into Textile Machinery.** *G. W. Knapp*, General Electric Company

CP. Engineering Safety Into Electric Equipment.** *C. F. Hedlund*, Associated Factory Mutual Insurance Companies

12 :30 p.m. Textile Luncheon

Chairman: R. J. Demartini

Can the Textile Industry Afford Engineers?: Robert Browning; Booz, Allen and Hamilton, New York City

2 :30 p.m. Textile

Chairman: V. F. Sepavich

CP. An Integrally Engineered Machine Is Economically Desirable.** *R. A. Hudson*, Saco-Lowell Shops

CP. The Value of the Engineer in the Textile Mill.** *L. A. Runton*, Alexander Smith, Inc.

AIEE Board of Directors Holds Meeting at Institute Headquarters

A regular meeting of the AIEE Board of Directors was held at Institute headquarters, New York, N. Y., on January 22, 1953.

The minutes of the meeting of the Board of Directors held in New Orleans, La., on October 16, 1952, were approved.

EXECUTIVE COMMITTEE

Actions of the Executive Committee on membership applications as of October 23, December 4, and December 26, 1952, were reported and confirmed, as follows: October 23—54 applicants transferred and 7 elected to the grade of Member; 142 applicants elected and 14 re-elected to the grade of Associate Member; 22 applicants elected to the grade of Affiliate; 203 Student members enrolled. December 4—72 applicants transferred, 4 elected, and 3 re-elected to the grade of Member; 189 applicants elected and 14 re-elected to the grade of Associate Member; 27 applicants elected to the grade of Affiliate; 1,185 Student members enrolled. December 26—32 applicants transferred and 3 elected to the grade of Member; 188 applicants elected and 11 re-elected to the grade of Associate Member; 15 applicants elected to the grade of Affiliate; 233 Student members enrolled.

BOARD OF EXAMINERS

Recommendations adopted by the Board of Examiners at meetings held on October 16, November 20, and December 18, 1952, and January 15, 1953, were reported and approved, including the following: 36 applicants transferred, 5 elected, and 3 re-elected to the grade of Member; 116 elected and 13 re-elected to the grade of Associate Member; 83 Student members enrolled.

The Board of Examiners submitted nine proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite nine Members to be transferred to the grade of Fellow, and to approve the citations, as follows:

Joseph W. Allen Senior Electrical Engineer, Eclipse Pioneer Division, Bendix Aviation Corporation, Teterboro, N. J.
"For pioneering and outstanding achievement in the development of electric systems and equipment for aircraft."

Andre Gabriel Clavier, Technical Assistant to President, Federal Telecommunication Laboratories, Inc., 500 Washington Avenue, Nutley 10, N. J.
"For pioneer work in research, development, and engineering in communication in the microwave field."

Albert Armstrong Nims, Chairman, Electrical Engineering Department, Newark College of Engineering, 367 High Street, Newark, N. J.
"For outstanding contributions to the electrical engineering profession in the theory and design of arc-welding equipments, armature windings of electric machines, and in electric network analysis. Also, outstanding contributions to the engineering education."

Minot Harrison Pratt, Division Engineer, Niagara Mohawk Power Corporation, 300 Erie Boulevard, West Syracuse 2, N. Y.
"For outstanding contributions in the development of improved methods and equipment essential to the efficient operation of a major electric distribution system."

George B. Scheer, Chief Consulting Electrical Engineer, Kaiser Industries, 1924 Broadway, Oakland 12, Calif.
"For outstanding achievements, ingenuity, and broad engineering ability in designing power supply and electric equipment layout for aluminum reduction plants and steel mills, including a number of electrical applications new to the industry."

Kilburn M. Smith, System Planning Engineer, Engineering Department, Commonwealth Edison Company, 72 West Adams Street, Room 950, Chicago 90, Ill.
"For contributions to the field of power system engineering, particularly in the pioneering of high-voltage transmission of bulk power in densely loaded areas."

Demitri Trone, Chief Engineer, General Electric Company, Rio de Janeiro, Brazil
"For pioneering activities in electric power generation on the electrification of transportation system in foreign fields particularly in Russia and Brazil."

William W. Wishard, Assisant Chief Electrical Engineer, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.
"For outstanding contributions and originality in the application of high-voltage subtransmission systems to high-density load areas, and for sound engineering judgment and able leadership of an engineering organization of a large utility system."

John C. Woods, Station Design Engineer, Commonwealth Edison Company, 72 West Adams Street, Room 708, Chicago 90, Ill.
"For contributions in the field of electrical control of large turbogenerators and improvements in substation design contributing to their reliability and economy."

In accordance with a request by the Board of Directors at its October meeting, Messrs. Barrett and Hibshman submitted on behalf of the Board of Examiners, a proposed statement to the membership calling attention to the essential changes in the Constitution and Bylaws relative to membership requirements. The statement was endorsed with a request that it be given proper dissemination to the membership (*see pp 281-4*).

FINANCES

Past Chairman Walter J. Barrett of the Finance Committee reported disbursements from general funds as follows: October 1952, $126,718.40; November 1952, $82,873.90; December 1952, $68,197.48. Chairman C. S. Purnell, who took office on January 1, 1953, when Mr. Barrett became Treasurer, reported for January 1953 expenditures of $76,549.25. The report was approved.

Copies of a comparative statement of income and expenses during the expired portion of the present budget year were distributed. Attention was called to the necessity of meeting an increase in printing costs amounting to $16,000, during the remainder of the budget year, and the budget was amended accordingly.

The Board adopted a resolution to drop from membership any person owing dues for the fiscal year which began May 1, 1951, with the understanding that the suspended member may become reinstated without the formality of an application for reinstatement if dues in arrears are paid prior to May 1, 1953.

Upon recommendation of the Finance Committee, the Secretary was authorized to accept, during the fiscal year beginning May 1, 1953, payment of membership dues on the basis of the par currency value of countries affected by abnormal exchange rates—the member concerned to be granted an exchange allowance corresponding to the difference between the New York exchange value and the normal par of his currency, such allowance not to exceed 40 per cent of the dues payable and not to apply to purchases of or subscriptions to Institute publications; a corresponding reduction in appropriation payments to be applicable to Institute Sections in any countries affected.

RECOMMENDATIONS AND REPORTS

On account of the receipt of a gift of funds, the income from which is to supplement the income from the original Edison Medal fund, and upon recommendation of the Edison

Eminent Members of Eta Kappa Nu

At the Eta Kappa Nu dinner held on January 19, 1953, during the AIEE Winter General Meeting in New York, N. Y., four members of the Institute were introduced as newly inducted Eminent Members of the electrical engineering honor society. Shown here are, left to right: A. B. Zerby, Executive Secretary, Eta Kappa Nu; C. A. Powel (Eminent Member), Massachusetts Institute of Technology; E. T. B. Gross, Vice-President, Eta Kappa Nu; Philip Sporn (Eminent Member), American Gas and Electric Company; E. C. Molina (Eminent Member), Newark College of Engineering; Harold Pender (Eminent Member), Moore School of Electrical Engineering, University of Pennsylvania; E. B. Kurtz, President, Eta Kappa Nu

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Medal Committee, certain amendments to the bylaws of that committee were adopted to revise the provisions for paying for the medal and certificate.

Upon recommendation of the AIEE members in Ireland, Gerard M. Mulhern was appointed Local Honorary Secretary for Ireland for a term of 2 years.

The Sections Committee recommended and the Board approved the establishment of the Hamilton Section, from a Subsection of the Toronto (Ontario, Canada) Section, effective May 1, 1953, and the establishment of the Mobile-Pensacola Section, from a Subsection of the Alabama Section, effective immediately.

The Board of Directors approved a recommendation of the Committee on Student Branches that the presentation of papers by winners of District Branch competitions at the Summer General Meeting be discontinued, but that the winners be introduced at the general session of that meeting.

The Board also approved a recommendation of the Committee on Student Branches that a Student Branch be established at Saint Louis University, St. Louis, Mo.

Upon recommendation of the Committee on Planning and Co-ordination, locations and tentative dates for two meetings were approved: 1954 Combined Summer and Pacific General Meeting, San Francisco, Calif., June 21–25; and 1954 Fall General Meeting, Chicago, Ill., October 25–29.

The committee reported upon further consideration of the desirability of revising the geographical Districts and the appointment of a subcommittee to make recommendations.

Upon recommendation of the Sections committee and the Committee on Constitution and Bylaws, the Board of Directors voted to submit to the membership a proposed amendment of Section 58, Article IX, of the Constitution covering duties of Section chairmen.

The Board adopted amendments to Sections 2, 12, 13, 50, and 85 of the Bylaws, as follows:

Section 2. Paragraph 2 amended to read as follows:

The data required by Section 11, Article III, of the Constitution to be submitted to the Board of Directors recommending the conferral of the Fellow grade on a Member shall be interpreted to include a full record of education, professional development, and significant experience of the candidate with special emphasis on the accomplishments which evidence the achievement of distinction as required by Section 4 of Article II of the Constitution; and a summary of the candidate's outstanding accomplishments to serve as a basis for the citation to accompany the conferral of the Fellow grade.

Section 12. Second sentence, Paragraph 2, amended to read as follows:

.... Persons admitted to the Associate Member or Affiliate grade upon the expiration of their term of Student membership shall not be required to pay the entrance fee.

Section 13. Amended to read as follows:

For Fellows, twenty (20) dollars.

For Members, fifteen (15) dollars.

For Associate Members, fifteen (15) dollars; the first six (6) years of membership in Associate Member or Affiliate grade, including any prior membership in either grade, to be at a reduced rate of ten (10) dollars.

For Affiliates, fifteen (15) dollars; the first six (6) years of membership in Affiliate grade to be at a reduced rate of ten (10) dollars.

The following resolution, adopted earlier in the meeting, is to be used in connection with Section 13 of the Bylaws during the period of transition:

RESOLVED: that the reduction in dues of Affiliates to ten(10) dollars per year shall not be retroactive in the case of Affiliates now on the rolls; such Affiliates shall be entitled to the reduction for the remaining portion of their first six (6) years of membership.

Section 50. Paragraph "b" amended to read as follows:

(b) To exchange views and experiences in connection with activities and management of Sections and to make recommendations of an advisory nature upon such matters, through the Sections Committee, to the Board o Directors.

Second sentence of Paragraph "d" amended to read as follows:

(d).......... The chairman of the Sections Committee shall appoint a subcommittee, consisting of the chairman and three other members of the Sections Committee, who shall prepare in advance of the general meeting a program of such questions for discussion.

Section 85. Amended to read as follows:

The Sections Committee shall consist of a minimum of 20 appointed members; each geographical District shall be represented by at least one member and one member shall be a member of the Board of Directors.

The committee shall sponsor and be responsible for the promotion of Section activities and the formation of new Sections and shall recommend changes in Section territory assignments. The committee shall confer with the Section officers and it shall consider, investigate, and make reports and recommendations to the Board of Directors for action on all matters regarding or involving the interest and welfare of the Sections or their relations with the Institute or other organizations. The committee shall arrange for and hold an annual meeting of the Section delegates during the Summer General Meeting of the Institute.

Reports were received from other committees and representatives on joint organizations.

APPOINTMENTS

The following appointments were made:

Board of Trustees, AIEE Retirement System—James F. Fairman for remainder of term ending July 31, 1955, succeeding F. M. Farmer, resigned

Celebration in 1956 of 250th Anniversary of Benjamin Franklin's Birth—H. H. Sheppard

Alfred Noble Prize Committee—Professor E. W. Boehne for term of 5 years

Hoover Medal Board of Award—Professor D. D. Ewing for term of 6 years

Engineers Joint Council (EJC)—C. S. Purnell as an additional representative, and F. R. Benedict and N. S. Hibshman as additional alternates, all for year 1953

Joint AIEE–Institute of Radio Engineers (IRE) Co-ordination Committee—Walter J. Barrett reappointed for term of 2 years

Joint AIEE–IRE Student Branch Co-ordination Subcommittee—Professor R. T. Weil reappointed for term of 2 years

American Academy of Political and Social Science, Fifty-Seventh Annual Meeting, Philadelphia, April 10–11, 1953—L. R. Gaty and R. L. Goetzenberger

University of California: Inauguration of Chancellor, Los Angeles Campus—R. W. Sorensen. Inauguration of Chancellor, Berkeley Campus—D. I. Cone

The President was empowered to appoint two representatives to the Council of the American Association for the Advancement of Science, and later reappointed J. W. Barker and I. Melville Stein for a term of 2 years.

The Board voted to grant its consent to the service of N. S. Hibshman as a member of the Board of Directors of the Engineering Societies Personnel Service, Inc.

A list of Institute members who had been recommended for EJC committees was approved.

ATTENDANCE

Present at the meeting were: *President* D. A. Quarles; *Past Presidents* T. G. LeClair (afternoon), and F. O. McMillan; *Vice-Presidents* W. L. Cassell, W. Scott Hill, M. D. Hooven, Thomas Ingledow, E. S. Lammers, Jr., C. M. Lytle, F. W. Norris, J. S. Strasbourger, and W. R. Way; *Directors* F. R. Benedict, R. F. Danner, E. W. Davis, D. D. Ewing, L. F. Hickernell, A. C. Muir, N. C. Pearcy, C. S. Purnell, Elgin B. Robertson, H. J. Scholz, and Victor Siegfried; *Treasurer* Walter J. Barrett; *Secretary* H. H. Henline; and *Assistant Secretary* N. S. Hibshman.

Program Announced for Jointly Sponsored 1953 Electronic Components Symposium

Judging by advance requests for information, more than 1,500 scientists, engineers, and executives will attend the 1953 Electronics Components Symposium to be held at the Shakespear Club in Pasadena, Calif., April 29–May 1, 1953. The 3-day meeting is being sponsored by the AIEE, Institute of Radio Engineers, Radio-Television Manufacturers Association, and the West Coast Electronic Manufacturers Association.

Six sessions have been scheduled for the symposium. Dr. Simon Ramo, Hughes Aircraft Company, will be chairman of the first session, at which the subject to be covered will be "Critical Problems Being Faced by the Electronics Industry on Meeting Industrial and Military Demands."

All sessions are open to the public. Advance registration may be made through the symposium headquarters at The Stanford Research Institute, Los Angeles Division, 621 South Hope, Los Angeles 17, Calif. Dr. A. M. Zarem of the Stanford Research Institute is General Chairman.

Wednesday, April 29

8:00 a.m. Registration

9:45 a.m. Welcome

A. M. Zarem, General Chairman, 1953 Electronic Components Symposium, Stanford Research Institute, Los Angeles, Calif.

10:00 a.m. Session 1—General

Chairman: Simon Ramo, Hughes Aircraft Company, Culver City, Calif.

The Development of Industry Standards by the RTMA. *R. R. Batcher*, Radio-Television Manufacturers Association.

Inferences From Tests of Electronic Ordnance. *B. P. Ramsay*, United States Naval Ordnance Laboratory

A Critical Compilation of Electronic Information. *Richard Larson*, Vitro Corporation of America

The Component Problem in Industrial Electronics. *E. D. Cook*, General Electric Company

12:00 noon. Luncheon

Luncheon Address: Speaker and subject to be announced

1:45 p.m. Session 2—Environment and Packaging

Chairman: A. W. Rogers, Signal Corps Electronics Laboratory, Fort Monmouth, N. J.

Protective Coatings for Etched Circuit Wiring. *Morris Weinberg, L. J. Martin*, Hughes Aircraft Company

Review of Component Progress for Auto-Sembled Electronic Equipments. *V. J. Kublin, R. A. Gerhold*, Signal Corps Engineering Laboratory

Components for Mechanized Production of Electronic Equipment. *L. K. Lee, F. M. Hom*, Stanford Research Institute

Recommended Temperature-Measuring Techniques and Ratings for Electronic Parts. *J. P. Walsh*, Cornell Aeronautical Laboratory, Inc.

The Behavior of Component Parts in High-Intensity Short-Duration Environments. *C. R. Gates, F. A. Paul*, California Institute of Technology

Temperature-Pressure Derating of Electron Tubes. *Bernard Smith*, Wright-Patterson Air Force Base

6:30 p.m. Dinner

Dinner Address: Speaker and subject to be announced

Thursday, April 30

9:30 a.m. Session 3—Tubes and Tube Reliability

Electron Device Reliability Versus Postwar Equipment Complexity. *J. E. Gorham*, Signal Corps Engineering Laboratories

Statistical Control of Electron-Tube Reliability. *A. J. Heitner*, Sylvania Electric Products, Inc.

Performance of Vacuum Tubes in Military Applications. *E. R. Jervis, R. Madison*, Aeronautical Radio, Inc.

Reliability—Tubes Versus Transistors. *C. W. Martel*, Raytheon Manufacturing Company

Improving Equipment Reliability by Tube Aging and Inspection. *R. E. Colander*, Bendix Aviation Corporation

12:00 noon. Luncheon

Luncheon Address: Speaker and subject to be announced

1:45 p.m. Session 4—Reliability

Chairman: M. Barry Carlton, Research and Development Board, Department of Defense, Washington, D. C.

The Case of Reliability Versus Defective Components et al. *R. M. C. Greenidge*, Bell Telephone Laboratories

The Necessity of Statistical Experimental Design in Testing for Component Reliability. *J. L. Blair*, Consolidated Vultee Aircraft Corporation

Rudiments of Good Circuit Design. *N. H. Taylor*, Massachusetts Institute of Technology

Reliability of Transistors. *R. M. Ryder, W. R. Sittner*, Bell Telephone Laboratories

4:00 p.m. Round-Table on Reliability

Participants: The authors of the papers in Thursday's sessions, and R. R. Carhart, The Rand Corporation, and R. Lusser, Los Angeles Ordnance District Office, United States Army

Friday, May 1

9:30 a.m. Session 5—Resistors, Capacitors, and Dielectrics

Chairman: Louis Kahn, Aerovox Corporation, New Bedford, Mass.

Characteristics and Applications of Voltage-Sensitive Dielectrics. *G. S. Shaw, J. L. Jenkins*, Radiation, Inc.

Some Characteristics and Limitations of Capacitor and Resistor Components. *J. K. Sprague, Leon Podolsky*, Sprague Electric Company

New Developments in General-Purpose Ceramic Dielectric Capacitors. *A. K. Das Gupta, W. G. Delp*, Solar Manufacturing Corporation

Recent Developments in Dielectric Materials Related to Component Development. *G. T. Kohman*, Bell Telephone Laboratories

Quality Components and Improved Dielectrics. *A. J. Warner*, Federal Telecommunication Laboratories, Inc.

2:00 p.m.

Chairman: Reuben Lee, Westinghouse Electric Corporation, Baltimore, Md.

New Ferritic Materials. *Ephraim Gelbard*, General Ceramics and Steatite Corporation

Ferro-Resonant Devices. *Hugo Woerdemann*, Magnetic Research, Inc.

Transformer Design Limitations. *R. M. Hanson*, Transonic, Inc.

Selenium Rectifier Characteristics and Limitations. *G. B. Farnsworth*, General Electric Company

Contact Phenomena as Related to Miniaturization. *Frank Spayth*, P. R. Mallory and Company Inc.

Southern Textile Conference to Be Held at Georgia Tech

The Textile Electrical Conference sponsored by the AIEE Subcommittee on the Textile Industry each year for members and guests in the South, will be held in Atlanta, Ga., at the A. French Textile School of the Georgia Institute of Technology, April 23–24, 1953.

The morning session on Thursday, April 23, will be devoted to the discussion of the practical merits of the present ungrounded 550-volt 3-phase 60-cycle 3-wire power versus the proposed grounded neutral 3-phase 550-volt 60-cycle system under consideration by several engineering concerns. There will be two speakers on this subject.

The Thursday afternoon session with three speakers will be devoted to lightning and lightning protection for various arrangements of textile mill buildings.

The session planned for Friday morning will feature discussion of motor torque requirements, motor overcurrent protection, and control connections. The concluding session will cover various phases of electrical maintenance in textile plants.

The discussion panel promises to present some unusual viewpoints on these subjects, and should interest the maintenance and operating personnel of every mill in the area.

New Developments Subject of Western Computer Conference

Important new developments in the electronic computer field are emerging at an increasing rate, in many sections of the United States. The impact of this program will pose a growing problem of scientific manpower shortages, and some day this field of automatic intelligence may be the greatest single user of engineers and scientists. This is the picture of the field painted at the Western Computer Conference held at the Statler Hotel in Los Angeles, Calif., February 4–6, 1953.

The 3-day conference, sponsored jointly by the Association for Computing Machinery, the Institute of Radio Engineers, and the AIEE, was attended by approximately 800 electronic engineers and potential users of the new electronic computers. In addition to the technical sessions, more than 20 firms and organizations displayed latest developments in computer equipment.

Keynoting the conference were addresses by Dr. Simon Ramo, vice-president of Hughes Aircraft Company, and Dr. R. D. Huntoon, Chief of the Corona (Calif.) Laboratories of the National Bureau of Standards. Dr. Ramo pointed out that ultimately the universities must turn out a new kind of doctor whose studies include the physical sciences, with emphasis on electronics, a study of the human brain (nature's example of a thinking machine), methods and procedures in business and industry, and government and labor rules and regulations. Even today, with the computer field in its infancy, the shortage of properly trained scientists and engineers is a bottleneck, he said.

Dr. Huntoon suggested that Darwin's theories apply to the evolution of "electronic brains" as well as to living ones; computing machines, in order to survive and prosper,

Dr. Simon Ramo addresses the Western Computer Conference

must adapt to their environment. At the same time, he pointed out that users of these machines must be willing to think in terms of machine language.

In the technical sessions, a number of new developments and applications of computing equipment were described. A decimal computer capable of processing the weekly payroll for an organization of 4,000 to 5,000 employees, at the rate of 30 seconds per employee, was described. Another machine under development will sort, collate, select, and process more than 10,000 documents an hour, and process the information they contain, without regard to the size, shape, thickness, flatness, or degree of preservation of the documents being handled.

A look into the future of high-speed printing was presented, with a description of a magnetic reproducer and printer now under development. This machine will record automatically the subject matter (which may be the output of a computer) on a magnetically sensitive surface, after which the image would be developed by using a magnetic ink. This device promises not only to provide much higher printing speeds than present-day mechanical printers, but also can turn out any desired number of copies in the same manner as a newspaper printing press.

Another paper described the application of present-day computing equipment for the elimination of bottlenecks in the production of aircraft and similar industries. Diagrams were shown of such a system designed for a Los Angeles area firm, which would pay for itself in less than 3 years on clerical savings alone. The computing equipment would take over many of the routine paper work jobs now being handled by clerks, but would leave the important decisions up to the production managers.

The computer exhibits also presented new advances in the computer field. Two organizations chose this conference for the unveiling of new analogue computers. One of these is a compact electromechanical differential analyzer, useful in the solution of mathematical equations encountered in aircraft design. The other is a high-precision electronic analogue computer, with an accuracy of 1/100 of 1 per cent.

Also exhibited was a model of a new large-scale digital computer, shown for the first time at a computer convention. This machine was released only recently for public knowledge from its security cloaks, and is considered one of the largest and fastest machines of its kind.

Ridgway Section Establishes Scholarships, Provides Guidance

The Institute has been active for some time in encouraging Sections to take action in their respective areas to interest high school graduates in entering the engineering profession. As a result, the AIEE Ridgway (Pa.) Section has developed a vocational guidance program for the high schools and has succeeded in establishing an engineering scholarship for residents of Elk County in Pennsylvania.

The Section, then the Ridgway Subsection, began its project in 1950 when it arranged to have leading engineers speak in high schools in the area. In 1952 the Subsection developed the idea of sponsoring an engineering scholarship to be financed by the industries of the communities in the area. Excellent response from the industries of Elk County, but an inadequate response from the other counties, made it possible to establish an Elk County Engineering Scholarship, rather than one sponsored by the entire Section.

Funds for the first scholarship, to be awarded this spring, were raised through the efforts of a Vocational Guidance Committee. These funds have been placed in a trust fund for disbursement to the winner over a 4-year period. The committee also prepared a set of rules, which specify that one scholarship will be granted each year to a graduate of an Elk County high school, who is a resident of the county. Winners will be selected on the basis of an academic examination, engineering and physical science aptitude test, and information provided by the high school principal. Winners may attend any accredited engineering college in the United States, and may choose any recognized field of engineering. The amount of the scholarship may vary from year to year, depending upon economic conditions and the ability of the donors to contribute.

As some indication of the progressive success of the program since 1950, one high school principal has reported that interest in the engineering profession has grown fourfold in his school in that period. Other Sections interested in instituting similar programs to encourage qualified high school graduates to consider engineering as a profession, can obtain further details of the Ridgway Section's program from C. F. McGinnis, Chairman, Ridgway Section Vocational Guidance Committee; Elliott Company, Ridgway, Pa.

Philadelphia Section Initiates Series of Weekly Broadcasts

As a result of the efforts of its Publicity Committee, the AIEE Philadelphia Section soon will sponsor a series of weekly 10-minute public interest radio programs. Known as "Headlines of Engineering," the series is to be broadcast over station *WFLN* and will consist of interviews, by a member of the Section, of prominent specialists on subjects most likely to highlight outstanding accomplishments in electrical engineering which

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Summer General Meeting Headquarters

Chalfonte-Haddon Hall photo

The Chalfonte-Haddon Hall in Atlantic City, N. J., which is to be headquarters for the AIEE Summer General Meeting, June 15–19, 1953. Host for this meeting will be the AIEE Philadelphia Section

are of greatest general public interest. The programs are scheduled to begin on April 1 at 7:45 p. m.

This activity has grown out of the Golden Anniversary dinner of the Philadelphia Section on February 9, 1953, when the Publicity Committee played host to the Philadelphia press. All of the city's newspapers and several of the radio stations were represented.

In conjunction with the broadcasts, a committee under the chairmanship of M. L. Stoughton will set up the programs and select members of the Institute to participate.

Program Announced for Fifth Rubber and Plastics Conference

The tentative program has been released for the Special Technical Conference on Electrical Engineering Problems in the Rubber and Plastics Industries to be held at the Mayflower Hotel in Akron, Ohio, April 20–21, 1953. This will be the fifth annual conference on this subject.

The present schedule for the conference is as follows:

Monday, April 20

Power Distribution Layouts for Tire Plants. *J. R. Dorsey*, B. F. Goodrich Company

Fuse and Relay Co-ordination in Industrial Plants. *N. A. Williams*, Goodyear Tire and Rubber Company. Prepared discussion by *K. W. John*, United States Rubber Company

Electrical Procedures in Tire-Testing Equipment. *Harold Lamb*, Adamson United Engineering Company

Remote Electrical Transmission of Physical Data for Rubber and Plastics Plants. *W. D. MacGeorge*, Automatic Temperature Control Company

Grounding of Power Systems in Rubber and Plastics Manufacturing Plants. *D. F. Langenwalter*, *L. F. Lewis*, General Electric Company

Tuesday, April 21

Servomechanisms—Automatic Feedback, Practical Applications. *C. M. Edwards*, Bendix Research Laboratories

Current Limit Power Fuses for High-Interrupting-Capacity Controllers. *C. Colby*, Firestone Tire and Rubber Company

Atomic Power for War and Peace. R. J. Kryter, The Esterline-Angus Company, Inc.

Inspection trip through the B. F. Goodrich Company's main plant, Akron

It has been announced also that Special Publication *S51* covering the papers presented at the third and fourth conferences on this subject, in 1950 and 1952, is now available. It can be obtained from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y., at $3.50 per copy.

Railroad Presents Locomotive Bell to Mo. School of Mines Branch

At formal ceremonies in Rolla, Mo., on February 12, 1953, E. F. Tuck, Superintendent of Motive Power for the St. Louis–San Francisco Railway Company, presented a steam locomotive bell to the Missouri School of Mines and Metallurgy Student Branch of the AIEE and the Institute of Radio Engineers (IRE). The bell was accepted by G. F. McCormick, Chairman of the Student Branch, who in turn presented it to Dr. C. L. Wilson, dean of the school, and to William Patterson, president of the Student Council.

Left to right: F. G. Baker and E. F. Tuck, St. Louis–San Francisco Railroad; C. L. Wilson, dean of the University of Missouri School of Mines and Metallurgy; and G. F. McCormick, president of the Missouri School of Mines AIEE-IRE Student Branch, with the locomotive bell presented by the railroad to the school

The bell, suitably engraved, replaces one which was formerly used to celebrate the school's athletic victories and which for many years hung in the tower of the school's first building, the Rolla Building. It was removed when the tower was torn down in a modernization program, and subsequently was damaged and became useless.

Hearing of the situation from AIEE Student members, the railroad agreed to restore a lost tradition to the Missouri School of Mines campus, and presented the new bell, which will be mounted on the roof of the school's Jackling Gymnasium. The bell will be rung by compressed air, by a mechanism designed and fabricated by the St. Louis–San Francisco Railroad.

Following the presentation ceremonies, F. G. Baker, Diesel Supervisor for the railroad, talked to the AIEE-IRE Branch on the subject, "Diesel Electrification Brings New Problems to the Railroad." Mr. Baker stressed the problems that diesel motive power has brought to the railroads since it was first introduced in the 1940's. However, he pointed out the increased economy of operation of diesel locomotives over that of steam locomotives as illustrated by the fact that today one tank car of oil does the work that was formerly done with 10 to 12 carloads of coal, and that one spoonful of oil will carry one ton of freight one mile.

Pittsburgh Student Branch Reports Semester's Activities

The AIEE Student Branch at the University of Pittsburgh has recently concluded an outstanding semester of activities. An effort was made to present a program that would be of interest to undergraduate engineers and create the desire to participate in the various functions. The regularly scheduled meetings of the Branch were used as a time to bring men from industry and education before the student body in order that they might share their knowledge and experience with the students. Some of the subjects discussed at these meetings were: "The Financing of Political Parties" by Dr. E. D. Graper of the University of Pittsburgh Political Science Department; "The Services of Underwriters Laboratory, Inc." presented by L. F. Laur, representative of Underwriters Laboratory; and "The Value of Electronic Instruments in the Laboratory" by Dr. Peterson of the Mellon Institute.

The University of Pittsburgh was well represented at the District 2 Student Chairman and Counselors Meeting in Toledo, Ohio. Six Branch members accompanied the faculty advisor to the meetings. Many of the ideas presented at these meetings have been considered by the Branch officers and a few are to be tried during the spring semester in an effort to increase the student membership and promote interest in the AIEE among freshmen and sophomores.

The annual District field trip and prize-paper contest was held at the Springdale Power Station, Springdale, Pa., and the West Penn Power Company played host to Pennsylvania State College, West Virginia University, Carnegie Institute of Technology, and University of Pittsburgh. An inspection trip through the power station was arranged, followed by a luncheon and panel presentation of West Penn operations. The prize-paper contest was held following the panel discussion; Felix Cioca of the University of Pittsburgh was awarded 3d prize. The meeting was concluded by a dinner.

The semester's activities were closed with a banquet held in honor of the graduating seniors at which Louis Endsley, Pittsburgh consulting engineer, was guest speaker.

Tentative plans for the spring semester meetings include talks conducted by the Student members on subjects obtained from *Electrical Engineering*. It is hoped that this program will promote interest in the AIEE among nonmembers as well as provide speaking experience for the participating students; all graduating seniors are expected to contribute. One meeting during the term will be set aside for the prize-paper contest and a prize will be awarded by the Branch.

Student Branch officers and counselor for the year are: W. G. Vogt, Chairman; J. C. Chamberlin, Vice-Chairman; S. J. Whyte, Secretary; Professor R. C. Gorham, Counselor.

Additional Conference Papers Made Available by Authors

A list of Winter General Meeting conference papers which have been made available by their authors on request appeared in the March issue (*EE, Mar '53, pp 263–6*). A supplementary list follows. Readers desiring copies should write directly to the respective authors, at the addresses given.

Theory of Photoconductivity
Dr. H. Y. Fan, Physics Department, Purdue University, West Lafayette, Ind.

Motor Control Centers and Their Co-ordination With Distribution Systems
R. E. Gasparoli, General Electric Company, Control Engineering, 1 River Road, Schenectady, N. Y.

Electrical Innovations in the Alcoa Building
(L. N. Grier)
James J. Maloney, Aluminum Company of America, 1501 Alcoa Building, Pittsburgh 19, Pa.

Methods of Rating High-Interrupting-Capacity Controllers
John D. Leitch, Electric Controller and Manufacturing Company, 2700 East 79th Street, Cleveland, Ohio

Typical Installations
C. E. Pflug, care of Nash-Kelvinator Corporation, 5626 25th Avenue, Kenosha, Wis.

Overload Protection of Adjustable Voltage Drives
W. Schaelchlin, Westinghouse Electric Corporation, Genessee Street, Buffalo 5, N. Y.

Philadelphia Section Celebrates Golden Jubilee

With H. P. Liversidge, Chairman of the Board, Philadelphia Electric Company, setting the keynote for the meeting, the AIEE Philadelphia Section celebrated its Golden Jubilee at a dinner meeting on February 9, 1953.

After a social hour and festive dinner attended by 160 members and guests, L. R. Gaty, Chairman of the Philadelphia Section, introduced Mr. Liversidge who recalled a number of stories and incidents about past chairmen, speakers, and meetings, many of which were about the old controversial definition of power factor. Mr. Gaty also introduced two charter members, E. P. Coles and J. B. Klumpp, as well as the past chairmen who were present. D. C. Prince and N. E. Funk, past chairmen and past national presidents, spoke briefly.

Other speakers of the evening were J. C. Strasbourger, Vice-President, District 2, who discussed "The AIEE Becomes of Age," and outlined the big business AIEE has become with its increasing membership and activities; and E. H. Bauer, Westinghouse Electric Corporation, who described the "Development and Application of Jet Engines to Airplanes." This talk, which was illustrated by slides, elicited many questions from the audience on this phase of engineering development.

The Jubilee meeting was attended by some 225 members and guests.

Chairman L. R. Gaty cuts the anniversary cake at the recent dinner meeting celebrating the Golden Jubilee of the Philadelphia Section. Looking on are District 2 Vice-President J. C. Strasbourger (left) and H. P. Liversidge, a past chairman of the Section

COMMITTEE ACTIVITIES

***Editor's Note:** This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

Industry Division

Committee on Industrial Power Systems (*H. G. Barnett, Chairman; S. A. Warner, Vice-Chairman; R. H. Whaley, Secretary*). The committee has organized several subcommittees to carry on work in several sectors of its field, such as power supply to industrial plants; grounding of electric systems, circuits, equipment, and structures; distribution systems in industrial plants and in commercial buildings; characteristics of loads that occur in industrial plants and buildings; and codes and standards that pertain to the operation of these systems.

The Committee on Industrial Power Systems, jointly with the Committee on Insulated Conductors, sponsored two conference sessions at the 1952 Fall General Meeting where the problems and techniques involved in the use of aluminum conductors were discussed. The two committees sponsoring the sessions are now undertaking to publish these conference papers in booklet form.

The committee has developed in the past two publications covering the planning and characteristics of distribution systems in industrial plants and commercial buildings. It is planned that both of these publications will be revised and improved in the near future. The book on "Electric Power Distribution for Industrial Plants," popularly referred to as the "Redbook," is now undergoing revision.

The work on grounding has progressed as rapidly as present manpower limitations permit. Several papers and reports probably will result. At the 1953 Winter General Meeting there were three papers directly treating various aspects of grounding of systems and equipment. These papers and the discussions are steps toward a better understanding of the problems and effects of grounding.

The Subcommittee on Codes and Standards will take an active interest in the revision and formulation of codes and standards that affect the planning and operation of industrial and commercial building power systems. This subcommittee provides an effective channel for communicating the needs and opinions of industrial and commercial building electrical engineers to the code-formulating organizations.

Communication Division

Committee on Radio Communications System (*A. C. Dickieson, Chairman; E. D. Becken, Vice-Chairman; R. D. Campbell, Secretary*). The Committee on Radio Communications Systems is successfully meeting its immediate goal of presenting one session of radio papers at each of the general meetings. It is working actively to stimulate discussion and papers on the application of radio in the communication aspects of the utility, railroad, petroleum, and pipe-line industries.

Power Division

Joint Subcommittee on Application of Probability Methods to Power System Problems (Joint with Power Generation and System Engineering Committees) (*G. Calabrese, Chairman*). This joint subcommittee has set forth the following goals for itself and organized working groups to take care of this work as follows:

1. *Terminology and definitions.* This working group is to co-ordinate and ultimately standardize the terms to be used relative to power system reserve.
2. *Preparation of a manual on the application of probability methods to reserve capacity problems.* This working group is to co-ordinate and popularize the material published on the subject of power-system reserve by the probability method.
3. *The collection of outage data on high-pressure turbogenerators and boilers.* This working group is to bring up to date outage data on high-pressure boilers and turbogenerators. It has prepared an informal

preliminary report for the year 1951 which was discussed at the subcommittee meeting during the AIEE Winter General Meeting in January. Data for the year 1952 are being analyzed and, if possible, the subcommittee will present a report to the Institute covering the 2 years 1951–52 at the 1953 Fall General Meeting.

Science and Electronics Division

Committee on Electronic Power Converters (*I. K. Dortort, Chairman; C. R. Marcum, Vice-Chairman; J. B. Pitman, Secretary*). The committee's report on cooling and corrosion was not quite completed for the Winter General Meeting, but will be presented at the Summer General Meeting in Atlantic City. The committee extends its thanks to the many users of rectifiers who have contributed by their work in the group which prepared the report and by supplying statistical data.

Work is continuing on the preparation of standards for hot-cathode rectifiers, the study of the need of revision of Standard *C34*, and an effort to resolve the differences between *C34* and the proposed International Standards.

AIEE PERSONALITIES.....

1952 Lamme Medal Awarded to I. F. Kinnard

Isaac Fern Kinnard (AM '21, M '28, F '43), Manager—Engineering, Meter and Instrument Department, General Electric Company, West Lynn, Mass., has been selected to receive the 1952 AIEE Lamme Medal "for his outstanding contributions in design and developments in instrumentation and measurements." Mr. Kinnard was born in Ontario, Canada, on September 29, 1891, and graduated in 1918 from Queen's University, Kingston, Ontario, with a bachelor of science degree, having majored in electrical engineering and physics. After service in the Engineers Corps, Canadian Army, during World War I, he attended the University of Glasgow as a graduate student of mathematics and physics. From 1919 to 1922 he was a research engineer with the Westinghouse Electric Corporation, where he contributed to the development of magnetic materials as applied to instrument transformers. In 1922 he joined the engineering organization of the Meter and Instrument Department, General Electric Company, and has been the Engineering Manager of the department since 1930. Since assuming that position, Mr. Kinnard has contributed many basic improvements in electric measuring equipments. He holds 18 patents and has been the author of many AIEE papers on measuring devices. Mr. Kinnard's additional General Electric Company responsibilities have included the chairmanship of the company-wide Magnetic Materials Committee and membership on the Engineering and Research Council. Within the AIEE he has been a member of the Board of Examiners since 1946 and served for 18 years on the Instruments and Measurements Committee, including 2 years as its chairman. He also has been a member of many National Electrical Manufacturers Association (NEMA) and American Standards Association committees and subcommittees and since 1951 has been chairman of the NEMA Electrical Measuring Equipment Section.

Elgin B. Robertson Nominated for Institute President

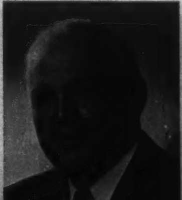
Elgin Barnett Robertson (M '24, F '45), President, Elgin B. Robertson, Inc., Dallas, Tex., has been nominated for the presidency of the AIEE for the 1953–54 term. Born on June 4, 1893, in Meridian, Tex., Mr. Robertson was graduated from the University of Texas in 1915 with the degree of electrical engineer. He was with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) from 1915 to 1920 and then became chief electrical engineer for the Railway and Industrial Engineering Company, Greensburg, Pa. In 1928 Mr. Robertson established the Elgin B. Robertson Company in Dallas, and since its incorporation has been its president. When the Plastics Manufacturing Company was formed he was made president and continues to hold that position. He joined the War Production Board as production engineer in 1942 and later was named regional utility engineer and regional manager of the Production Department. He has actively served the Institute as North Texas Section Secretary (1937–38), Section Chairman (1938–39), and on the following AIEE committees: Membership (1944–46); Board of Directors (1947–51, 1951–54); General Applications Division (1947–51); Registration of Engineers (1946–52, Chairman (1949–51); Planning and Co-ordinating (1946–53, Chairman 1952–53); Professional Division Advisory (1949–51); Lamme Medal (1951–54); Edison Medal (1952–54); and Executive (1952–53).

Vice-Presidential Nominees Are Morton, Almon, Anderson, Tenney, and Floyd

Walter Benson Morton (AM '25, M '28, F '42), station electrical engineer, Pennsylvania Power and Light Company, Allentown, has been nominated to serve the Institute as Vice-President representing the Middle Eastern District (number 2). Mr. Morton was born in Dallas, Tex., February 3, 1896. From 1915 to 1919 he was electrician and chief electrician in the United States Navy and from 1919 to 1923 was electrician and foreman at the Mare Island, Calif., Navy Yard. In 1923 he became a designer for the Pacific Gas and Electric Company, San Francisco, Calif., and was appointed construction foreman in 1924. In 1925 he joined the Alabama Power Company, Birmingham, as electrical designer, and in 1926 was placed in charge of the electrical design division of the engineering department. Mr. Morton joined the Philadelphia (Pa.) Electric Company in 1931 as project engineer, becoming senior project engineer in 1932 and senior field engineer in 1940. He served as a Commander in the United States Navy during World War II. Since 1945, Mr. Morton has been station electrical engineer, Pennsylvania Power and Light Company. Mr. Morton is a member of the Pennsylvania Electric Association and the Illuminating Engineering Society. He has served the AIEE as a director (1941–46) and as past secretary, manager, and chairman of the Philadelphia Section, and on the following Institute committees: Sections (1940–44); Membership (1941–43); Technical Program (1941–43); Transfers (1941–42);

Photo by Fabian Bachrach

I. F. Kinnard


Elgin B. Robertson

W. B. Morton

C. P. Almon, Jr.

A. S. Anderson

G. C. Tenney

G. D. Floyd

D. I. Cone

Land Transportation (1944–47); Marine Transportation (1945–46); and Planning and Co-ordination (1946–47).

Charles Pomeroy Almon, Jr. (AM '37, M '45, F '51), chief, Power System Operations Branch, Tennessee Valley Authority, Chattanooga, has been nominated to serve the Institute as Vice-President representing the Southern District (number 4). Mr. Almon was born on August 2, 1904, in Russellville, Ala., and was graduated from the University of Alabama in 1928 with a bachelor of science degree in electrical engineering. Following his graduation, he was employed by the Southeastern Engineering Company (later Allied Engineers), Birmingham, Ala., as an engineer in the Consulting and Planning Section. From 1931–33 he served first as test man and later as system load dispatcher with the Tennessee Electric Power Company, Chattanooga and Cleveland. He joined the Tennessee Valley Authority in November 1933 as assistant electrical engineer and assistant superintendent of the Wilson Dam, Ala., hydroelectric and steam plants. He became chief system operator in 1936 and chief, Power System Operations Branch, in January 1943. Mr. Almon is a member of Tau Beta Pi. He has served the AIEE in the East Tennessee Section as vice-chairman (1944–45), chairman (1945–46), and director (1946–47). He was secretary of District 4 from 1951–53, and has been a member of the AIEE Committees on Power Generation (1944–47) and System Engineering (1947–52).

Albert S. Anderson (AM '22, M '32, F '51), manager, Electric Utility Sales, Rocky Mountain District, Apparatus Sales Division, General Electric Company, Denver, Colo., has been nominated to serve the Institute as Vice-President representing the North Central District (number 6). Born on January 27, 1898, in Denver, Mr. Anderson was graduated from the University of Colorado in 1919 with the degree of bachelor of science in electrical engineering. He joined General Electric in 1919 at Schenectady, N. Y., and was transferred to the Denver office in 1920. In 1925 he was appointed District Manager, Central Station Department, which position he held until his appointment as manager, Electric Utility Sales. He served as chairman of the Denver Section of the AIEE in 1938 and on the Membership Committee (1937–39, 1949–50).

George Clinton Tenney (AM '35, M '42), editor and publisher, *Electrical West*, and vice-president, McGraw-Hill Publishing Company, San Francisco, Calif., has been nominated to serve the Institute as Vice-President representing the Pacific District (number 8). Mr. Tenney was born in Provo, Utah, July 13, 1898, and was graduated from the University of California in 1920 with a degree in electrical engineering. From 1921 to 1924 he was associate editor of the *Journal of Electricity* and subsequently, in 1924, managing editor. He kept that position when the name of the publication was changed to *Electrical West*. In 1930 he became editor and publisher of that magazine and since 1938 has directed all Pacific Coast operations of the McGraw-Hill Publishing Company. Mr. Tenney is a director and past president of the Pacific Coast Electrical Association and past president of the San Francisco Electric Club. He has served as secretary, vice-chairman, and chairman (1944) of the San Francisco Section of the AIEE and on the following Institute committees: Domestic and Commercial Applications (1944–51) and Publication (1949–53). Mr. Tenney was general chairman of the 1949 AIEE Pacific General Meeting.

George David Floyd (AM '19, M '28). Director of Planning, The Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada, has been nominated to serve the Institute as Vice-President representing the Canadian District (number 10.) Mr. Floyd was born at Westville, Nova Scotia, Canada, October 21, 1892, and was graduated from Dalhousie University in 1913. He received his electrical engineering degree from McGill University and joined Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation), East Pittsburgh, Pa., as an engineering apprentice, later becoming an instructor in electrical engineering and a graduate student at Cornell University, Ithaca, N. Y. His graduate studies were interrupted by World War I, in which he served as a pilot in the Royal Flying Corps. He joined the research staff of Ontario Hydro-Electric in 1919, and later was transferred to the electrical engineering department of that utility. Upon formation of the Planning Division in 1952, he became Director of Planning. Mr. Floyd was chairman of the Toronto Section of the AIEE in 1933–34, and has served on the following AIEE committees: Membership (1934–36); Electrical Machinery (1935–36); and System Engineering (1948–53). Mr. Floyd is a member of the Engineering Institute of Canada, the Canadian Electrical Association, and the Association of Professional Engineers of Ontario.

Cone, Linville, and Seeger Nominated for Directorships

Donald Isaac Cone (AM '15, M '24, F '42, Member for Life), transmission and protection engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif., has been nominated to serve on the AIEE Board of Directors. Mr. Cone was born in Eureka, Calif., July 31, 1891, and graduated from the University of California in 1913 with a bachelor of science degree in electrical engineering, having served as an assistant in physics from 1911–13. He joined Pacific Telephone and Telegraph Company in 1913 as an engineer, becoming protection engineer in 1920, and transmission and protection engineer in 1926. Mr. Cone is a member of the Institute of Radio Engineers, the Engineers' Club of San Francisco, and is a registered professional engineer. He has served as chairman of the San Francisco Section of the AIEE (1926) and as vice-president, District 8 (1947–49). He has served on the following Institute committees: Membership (1929–31); Communication (1946–47); and Edison Medal (1948–53).

Thomas Merriam Linville (AM '27, M '34, F '47), manager, Manager Development Services Department, Management Consultation Services Division, General Electric

T. M. Linville

E. W. Seeger

W. J. Barrett

Company, New York, N. Y., has been nominated to serve on the AIEE Board of Directors. Born in Washington, D. C., March 3, 1904, Mr. Linville was graduated from the University of Virginia in 1926 with an electrical engineering degree. He joined General Electric that same year on the Test Course in Schenectady, N. Y., transferring in 1927 to the Motor Engineering Division, Pittsfield, Mass. From 1928 to 1931 he was with the Engineering General Division in Schenectady taking the Advanced Course in Engineering. He served with the Aeronautics and Marine Engineering Division from 1932–33 and with the Motor and Generator Engineering Division, 1933–46. He joined the staff of the manager of engineering in 1947 and became management consultant in 1951. He attended the Graduate School of Business Administration, Harvard University, in 1950. During World War II, Mr. Linville served as a member of the United States Naval Technical Missions at Pearl Harbor in 1942 and in Europe in 1945. He received the Charles A. Coffin Award for "outstanding development of design methods for d-c machines and application to propulsion machines for submarines in World War II." Mr. Linville is a member of The American Society of Mechanical Engineers, American Society for Engineering Education, New York State Society of Professional Engineers, National Society of Professional Engineers, American Association for the Advancement of Science, Society for Advancement of Management, and the American Management Association. He has served as chairman of the Schenectady Section of the AIEE (1942–43) and on the following Institute committees: Sections (1943–47); Rotating Machinery (1947–52); Education (1947–49); Membership (1950–51); Publication (1952–53); and as AIEE representative for the Alfred Noble Award (1948–53).

Edwin Wilbur Seeger (AM '16, M '19, F '36, Member for Life), vice-president and assistant secretary, Cutler-Hammer, Inc., Milwaukee, Wis., has been nominated to serve on the AIEE Board of Directors. Mr. Seeger was born in Bucyrus, Ohio, May 22, 1892. Following his graduation from Ohio State University in 1913, he joined Cutler-Hammer in the shop and engineering department, becoming general supervisor of the engineering department in 1922. He became assistant chief engineer in 1928, chief engineer in 1938, manager of development in 1939, and vice-president and assistant secretary in 1945. Mr. Seeger is a member of Eta Kappa Nu, Sigma Xi, Tau Beta Pi, National Society of Professional Engineers, Wisconsin Society of Professional Engineers, and the Engineers' Society of Milwaukee. He has served as vice-president, District 5 (1948–50), and chairman of the Milwaukee Section (1929–30) and on the following Institute committees: Automatic Stations (1927–29); Applications to Iron and Steel Production (1935–37); Board of Directors (1949–50), and Registration of Engineers (1949–51, 1952–53).

W. J. Barrett Nominated as Institute Treasurer

Walter J. Barrett (M '36, F '50), electrical co-ordination engineer, New Jersey Bell Telephone Company, Newark, has been nominated to serve the AIEE as Treasurer. Mr. Barrett was born in Brooklyn, N. Y., January 10, 1899, and was graduated from the Polytechnic Institute of Brooklyn in 1920 with the degree of electrical engineer. Upon graduation, he joined the American Telephone and Telegraph Company. In 1930, Mr. Barrett became a supervisor in the Engineering Department, New Jersey Bell Telephone Company. Mr. Barrett is a former director of the Institute (1950–52) and has served on many AIEE committees, including Finance, Planning and Co-ordination, Executive, Headquarters, and Lamme Medal. (*A complete biography of Mr. Barrett appeared in EE, Dec '52, p 1151.*)

Aram Boyajian (AM '18, F '26), electrical engineer, General Electric Company, Pittsfield, Mass., will retire on April 1, 1953. Mr. Boyajian has contributed many original papers on a wide range of subjects in electrical engineering: about 30 of them on the theory and characteristics of transformers, several on general circuit theory, others on mathematics, still others on engineering education, see "The Education of Tom, Dick, and Harry," *Technology Review*, March 1953, and some on philosophy, see "The Strange Trinity Called Man," *Scientific Monthly*, April 1946, and "A. A. Michelson Visits Immanuel Kant," *Scientific Monthly*, December 1944. Mr. Boyajian was born in 1888 in Armenia, and was educated there in the American Mission Schools, receiving the bachelor of arts degree in general arts from Anatolia College in 1908. He taught for 2 years and came to the United States in 1910 to escape Turkish persecution and to study further. Arriving in Philadelphia, Pa., he was apprenticed to an Armenian tailor and later opened a shop of his own in Swarthmore, Pa., to study electrical engineering at Swarthmore College while working in the village and in 1915 graduated with bachelor of arts degree in electrical engineering. He then sold his business and joined the General Electric Company, Pittsfield. Though a member of the transformer engineering staff of the General Electric Company, he has maintained a broad interest, including transmission lines, rotating machines, rectifiers, electronics, and chemistry. His latest activity has been to collaborate with several associates on a government project to develop design methods, and to design and build high-power high-voltage pulse transformers up to 50,000 kw at 240 kv. Although he is better known for his theoretical papers, he has been sufficiently interested in applied developments to obtain 18 patents bearing his name. His first contact with patents aroused his interest in patent laws and patent drafting, and so for many years he has acted as liaison between the Pittsfield Works engineering departments and the patent department of the General Electric Company, on occasions assisting also in litigation. Mr. Boyajian has always had a weekly class teaching transmission, rotating machines, advanced calculus, or electronics, the students consisting of co-operatives from Massachusetts Institute of Technology (MIT) with an assignment in Pittsfield. During the 1952–53 fall term, he was a visiting lecturer at MIT, on an experiment in education jointly sponsored by MIT and the Educational Committee of General Electric to conduct a course in engineering practice for seniors along a new idea in which the students are assigned a project in an unfamiliar field and they have to acquire quickly sufficient understanding of the theory of the subject to draw up competitive design specifications for the project. In the civic field, in 1939, Mr. Boyajian organized the Friends of the Berkshire Athenaeum to promote the welfare of the local free library, and since then the budget of the library was increased from about $30,000 a year to over $100,000. At the present time, he is a trustee of the library. For his contributions to his adopted country, Mr. Boyajian was honored at the New York World's Fair with his name on the "Wall of Honor" along with the names of other honored adopted Americans. For the immediate future, Mr. Boyajian expects to be busy professionally in industrial consulting and development, educational planning and lecturing, expert testimony in litigation, and writing.

W. A. Del Mar (AM '06, F '20, Member for Life), chairman of research and development committee, Phelps Dodge Copper Products Corporation, and chief engineer, Habirshaw Cable and Wire Division of that company, New York, N. Y., recently received the Fellowship of the City and Guilds of London Institute, the diploma of which was presented to him in London, England, by Prince Philip, Duke of Edinburgh. This degree is awarded to graduates of the City and Guilds College, a department of the University of London, for "outstanding contributions to the industry in which they are engaged." Mr. Del Mar has been a very active member of the Institute and has served on many committees including Board of Examiners, Headquarters, Publication, Standards, Executive, Transmission and Distribution, Protective Devices, Lamme Medal, and others.

V. E. Neilly (AM '49), assistant professor of engineering extension, Pennsylvania State College, State College, has been appointed secretary of the engineering college research council. He is a member of the American Society for Engineering Education, Eta Kappa Nu, and Tau Beta Pi.

C. G. Spencer (M '14, F '24, Member for Life), one of the founders of Baker and Spencer, Inc., New York, N. Y., has become vice-president of that company as the result of its affiliation with Frederic R. Harris, Inc., New York.

Morland King (AM '06, F '25, Member for Life), former professor and head, Electrical Engineering Department, Lafayette College, Easton, Pa., has become a consulting engineer at the Fairless Works of the United States Steel Company, Bucks County, Pa. Professor King retired from Lafayette College in June 1952.

F. J. Given (AM '28, M '48), apparatus and engineering director, Sandia Corporation, Albuquerque, N. Mex., has been appointed a member of the Advisory Group on Reliability of Electronic Equipment of the Department of Defense.

F. N. Wightman (AM '40, M '52), sales representative, **E. B. Scruggs** (AM '49), application engineer, and **B. H. Marshall** (AM '49), safety switch and panelboard sales engineer, Westinghouse Electric Corporation, St. Louis, Mo., have been appointed sales supervisors responsible for specific groups of application engineers in the St. Louis branch office.

E. S. Rehagen (AM '36, M '42), supervisor, electric utility department, Westinghouse Electric Corporation, St. Louis, Mo., has been appointed branch manager of the new St. Louis branch office. Mr. Rehagen joined Westinghouse in 1928, upon graduation from the University of Missouri, where he received a bachelor of science degree in engineering. He was formerly a district application engineer. He has been chairman of the St. Louis Section of the AIEE.

G. T. Hunter (AM '51), representative of the applied science department, International Business Machines Corporation, Philadelphia, Pa., has been appointed technical specialist in the applied science department, New York, N. Y. A graduate of the University of Tampa and the University of Wisconsin, Dr. Hunter joined International Business Machines in 1950 in Baltimore, Md. He subsequently served in New York, and in 1951 was advanced to the position from which he has just been promoted.

R. W. Ahlquist (AM '35, M '43), associate professor of electrical engineering, Iowa State College, Ames, has been appointed chairman of the Electrical Engineering Department, University of Detroit, Mich. After graduating from the Missouri School of Mines in 1924, Mr. Ahlquist joined Westinghouse Electric Company and became associated with the Westinghouse Technical Night School. He was made instructor at the University of Pittsburgh in 1926 and assistant professor in 1935. He joined the staff at Iowa State College in 1939.

OBITUARY • • • • • •

Stanley John Bruford (M '29), retired, died January 27, 1953, at Lympne, Kent, England. Mr. Bruford was born in Manchester, England, in 1888, and obtained his technical education at Armstrong College, Durham University. He served his apprenticeship with the Newcastle-on-Tyne Electric Supply Company, Ltd., rising to the post of senior assistant engineer. After service in World War I in the Royal Engineers, he became chief electrical engineer to the Government of Nepal. At that time, from 1921 to 1926, he and his wife were the only Europeans allowed to stay in Nepal. From 1927 to 1935 he was executive engineer on hydroelectric enterprises to the Punjab Government and in 1938 became resident engineer for the Pallivasal installations of the Government of Travancore. In 1946 he acted first as resident and then as chief engineer for the Government of Cochin and afterward for the combined Governments of Cochin and Travancore. He retired from that post in 1951. Mr. Bruford was a fellow of the Royal Geographical Society and the Royal Society of Arts and a member of the Institute of Structural Engineers and the Institution of Mechanical Engineers.

Emil E. Mayer (F '35), New Rochelle, N. Y., died January 30, 1953. Mr. Mayer was born in Elberfeld, Germany, July 1, 1885. He received his degree in engineering technology from the University of Munich in 1919. He had been employed previously by Allgemeine Elektrizitaetsgesellschaft, Berlin, Germany, as a test engineer, and later by Siemens-Schuckert and by Hochfrequenzmaschinen Aktiengesellschaft, also in Berlin, as a radio engineer. From 1913 to 1917 he was in charge of construction and operation of the radio station at Tuckerton, N. J. He returned to Germany in 1919 as chief engineer, Telefunken Company, Berlin, becoming vice-president in 1922. From 1924 to 1928 he was American representative at Schenectady, N. Y., of the German General Electric Company. He served as vice-president of German General Electric from 1928 to 1931, leaving to become president of Telefunken in Berlin. He came to the United States in 1934 and was a consulting engineer in New York, N. Y. Mr. Mayer was a fellow of the Institute of Radio Engineers. He was a member of the AIEE Board of Examiners (1951–53).

Charles Moon (M '47), chief, Inductance and Capacitance Section, National Bureau of Standards, Washington, D. C., died January 31, 1953. Dr. Moon was born in Ohiopyle, Pa., February 19, 1885, and received his bachelor's degree from West Virginia University, Morgantown, in 1910 and his doctor of philosphy degree in physics from Cornell University, Ithaca, N. Y., in 1922. After teaching 6 years at West Virginia and 4 years at Cornell, he joined the staff of the National Bureau of Standards as a physicist in 1923. He had been in his present position since 1946. For his services in the field of absolute electrical measurements, Dr. Moon had received the Department of Commerce Meritorious Service Award in 1952. He was a member of Sigma Xi, the Washington Academy of Sciences, and the Washington Philosophical Society.

Ausben R. Deck (AM '51), system engineer, Metropolitan Edison Company, Reading, Pa., died recently. Mr. Deck was born in Wilmington, Del., October 19, 1903, and was graduated from Lehigh University in 1924. Following his graduation he joined New Jersey Power and Light Company, Dover. The next year he was employed by the Metropolitan Edison Company, Easton, Pa., as substation equipment inspector. He returned to New Jersey Power and Light in Dover in 1926. In 1929 he was chief dispatcher for Metropolitan Edison in Easton. He was transferred to Reading in 1930. He was chief system operator for the company prior to his promotion to system engineer in 1948. He was a member of the System Planning Committee of the Pennsylvania Electric Association.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of February 19, 1953, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Atkinson, G. D., Jr., electrical supt., Bureau of Reclamation, Redding, Calif.
Barret, C. E., Anchorage, Ky.
Behm, H. J., principal electrical engineer, Battelle Memorial Institute, Columbus, Ohio
Black, H. A., operation & maintenance chief, U. S. Bureau of Reclamation, Billings, Mont.
Bonnet, R. W., design engineer, Duncan Electric Mfg. Co., Lafayette, Ind.
Brown, W. D., asst. supt., system operation, Duquesne Light Co., Pittsburgh, Pa.
Cutts, R., Jr., mgr. industry services section, General Electric Co., Schenectady, N. Y.
deGuise, Y., superintending engr., Quebec Hydro-Electric Commission, Montreal, Quebec, Canada
Garbarini, R. F., section head, Sperry Gyroscope Co., Great Neck, N. Y.
Hill, F. E., project engineer, Vickers Inc., Detroit, Mich.
Ivey, A. J., electrical engineer, Alabama Power Co., Birmingham, Ala.
Johnson, W. T., vice-pres. & executive engineer, California Electric Power Co., Riverside, Calif.
Kelch, R. V., senior meter engineer, Ohio Power Co., Canton, Ohio
Knox, J. L., missionary, American Baptist Foreign Mission Society, Iloilo City, P. I.
Leissring, E. H., asst. head station tester, Wisconsin Electric Power Co., Milwaukee, Wis.
Levada, A. R., asst. chief electrical engineer, General Electric, S. A., Rio de Janeiro, Brazil
Lucal, C. L., asst. supt. of meters, The Ohio Power Co., Canton, Ohio
Malkowski, H. F., meter & appliance supt., Blackstone Valley Gas & Electric Co., Pawtucket, R. I.
Marquette, F. W., project engineer, Duquesne Light Co., Pittsburgh, Pa.
McClure, F. N., electric utility engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Noakes, F., professor of electrical engineering, University of British Columbia, Vancouver, British Columbia, Canada
Roberts, W., manager, Osceola Electric Cooperative, Inc., Sibley, Iowa
Strawn, G. A., asst. professor of electrical engineering, University of Southern California, Los Angeles, Calif.
Tapley, J. G., system substation engineer, Appalachian Electric Power Co., Roanoke, Va.
Theobald, G., senior electrical designer, Public Service Electric & Gas Co., Newark, N. J.
Towner, J. M., senior engineer, Consolidated Gas, Electric Light & Power Co. of Baltimore, Md.
Williams, J. S., Jr., electric utility engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Zimmerman, W. O., Jr., development engineer, Duquesne Light Co., Pittsburgh, Pa.

28 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before April 25, 1953, or June 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Adams, N. G., International Engineering Company, San Francisco, Calif.
Buck, L. G., Bell Telephone Company of Canada, Montreal, Quebec, Canada
Carroll, S. O., Bureau of Ships, Washington, D. C.
Curtis, L. B. (re-election), Pennsylvania Railroad, Philadelphia, Pa.
Eichwald, B., B. Eichwald & Co., Inc., New York, N. Y.
Grandy, L. S. (re-election), U. S. Engineer Office, Mobile, Ala.
Hawkins, H. J., Canadian Westinghouse Co., Toronto, Ontario, Canada
Hunter, S. A., c/o Lancashire Dynamo & Crypto, Ltd., Birmingham, England
Ide, J. M., U. S. Navy Underwater Sound Lab., New London, Conn.
Loane, G. H., University of New Brunswick, Fredericton, New Brunswick, Canada
Lucking, W. T., Arizona Public Service Co., Phoenix, Ariz.
Paul, E. E., Howard, Needles, Tammen & Bergendoff, New York, N. Y.
Welch, J. B., Cutler-Hammer, Inc., Milwaukee, Wis.
Welch, W., Jr., Long Island Lighting Co., Mineola, N. Y.
Wilson, W. B., General Elec. Co., Schenectady, N. Y.

15 to grade of Member

OF CURRENT INTEREST

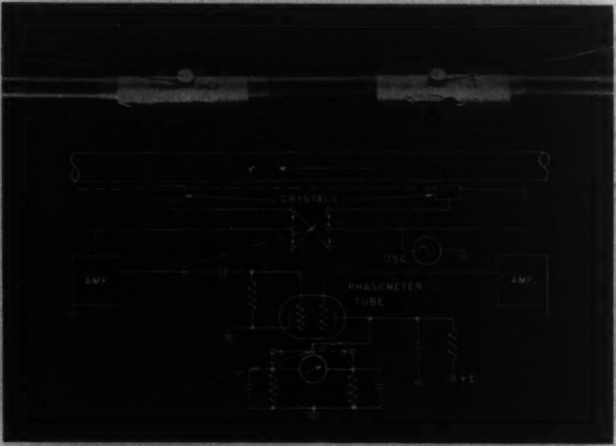
Electronic Flowmeter Is New Method for Measuring Air Currents or Fluid Flow

A new type of electronic flowmeter, capable of measuring the air currents in a still room or the rapid flow of fluids in pipes, has been developed recently at the National Bureau of Standards (NBS). This device utilizes the change in velocity of sound waves as a measure of fluid flow. It has a very fast response and does not obstruct the fluid currents to make the measurement. In addition, the signal-to-noise ratio is sufficiently high to permit the measurement of extremely small velocities.

Most of the present methods for measuring the velocity of flowing liquids depend on mechanical devices that usually introduce discontinuities in the fluid and have inherent inertia which prevents faithful reproduction of fast velocity changes. One type of flowmeter utilizes the principle of the homopolar machine; but this method cannot be used for gases, and the instrument is, at present, restricted to the measurement of conductive fluids. Another method makes use of the resistance change in hot wires placed in the path of fluid flow. However, besides presenting an obstruction to the flow, the hot wire is not generally applicable to fluids that would change chemically or physically as a result of the heat from the wires.

In the newly developed flowmeter, a sound wave is transmitted over a fixed distance through the flowing fluid, and the phase of the received wave is compared with that of the transmitted wave. The sound energy is imparted to and taken from the fluid through the walls of the containing vessel. No part of the measuring system need come in direct contact with the medium under study. This characteristic of the system makes the unit applicable to the measurement of blood flow in the aorta or for the detection of the flow of chemicals in a closed system, for example, the coolant in a chain reactor. Minor modifications will permit the measurement of the flow of such fluids as gas or oil in a metal pipe, or a determination of the relative velocity of a ship to that of the water through which it is moving.

In instances other than those involving extremely high velocities, that is, in wind tunnels, a simple system utilizing merely a stationary device to transmit energy into the medium and another stationary unit to receive it would be impractical because changes in distance or propagation velocity would produce errors far greater than the variations due to flow. For this reason, the transmitter and receiver of the new flowmeter are exchanged periodically without varying their locations. This is accomplished by using identical magnetostrictive or piezoelectric exciters, such as barium titanate crystals, as transmitter and receiver and by switching their connections alternately to the receiving and transmitting channel. Thus, the phasemeter displays two phase shifts alternately, one a function of the sound velocity plus the fluid flow and the other a function of the sound velocity minus the fluid flow. The difference between the two phase shifts is a measure of the velocity of the fluid. The switching can be made to operate faster than the inherent variations occurring in either the transmitter, receiver, or even the medium. Hence, the variations will occur at a minimum of one complete transmitter-receiver switching cycle, and the phase difference will remain unaffected.



Crystal arrangement (above) and circuit diagram (below) of a new electronic flowmeter. The flowmeter is capable of measuring the air currents in a still room or the slow or rapid flow of fluids in pipes. Sound waves are transmitted into the fluid through the walls of the container and are received by identical magnetostrictive or piezoelectric exciters. The transmitter and receiver of the new flowmeter are exchanged periodically by a switching system without varying their locations. The sound energy is amplified and passed on to a multigrid phasemeter tube. The output of the phasemeter is applied to an electronic voltmeter (which can be calibrated directly in terms of velocity) through a switch connected to the same drive that switches the crystals

Future Meetings of Other Societies

American Association of Spectrographers. Symposium on Emission Spectroscopic Determination of Metals in Non-Metallic Samples. May 1, 1953, Chicago, Ill.

Compressed Air and Gas Institute. May 4–6, 1953, King and Prince Hotel, St. Simons Island, Ga.

Electric Association and Electrical Maintenance Engineers. Chicago Electrical Industry Show. May 11–14, 1953, Conrad Hilton Hotel, Chicago, Ill.

Electrochemical Society. Spring Meeting. April 12–16, 1953, Hotel Statler, New York, N. Y.

Heat Exchange Institute. May 11–13, 1953, The Greenbrier, White Sulphur Springs, W. Va.

Institute of Radio Engineers. National Conference on Airborne Electronics. May 11–13, 1953, Dayton Biltmore Hotel, Dayton, Ohio

Institute of Radio Engineers—Polytechnic Institute of Brooklyn. Symposium on Nonlinear Circuit Analysis. April 23, 24, 1953, Engineering Societies Building, New York, N. Y.

Material Handling Institute. 5th National Materials Handling Exposition. May 18–22, 1953, Convention Hall, Philadelphia, Pa.

Metal Powder Association. 9th Annual Meeting. April 20–22, 1953, Hotel Cleveland, Cleveland, Ohio

Petroleum Industry Electrical Association. Annual Convention. April 7–9, 1953, Houston, Tex.

Research and Development Board, Panel on Electron Tubes. Symposium on Ceramic-to-Metal Seals. April 21, 1953, Rutgers University School of Ceramics, New Brunswick, N. J.

Society of Automotive Engineers. National Aeronautic Meeting. April 20–24, 1953, Hotels Statler, McAlpin, Governor Clinton, New York, N. Y.

Society of Photographic Engineers. 3d Annual Conference. May 20–22, 1953, Hotel Thayer, West Point, N. Y.

Society of the Plastics Industry. Annual Meeting and Conference. May 9–15, 1953, Cruise to Bermuda

The American Society of Mechanical Engineers. Spring Meeting. April 28–30, 1953, Deshler-Wallick Hotel, Columbus, Ohio

In the first experimental model of the

NBS flowmeter, a mechanical switching system operating at a 10-cycle-per-second rate is employed. The switching is achieved by a commutator that is inserted between the crystals on one side and a 100-kc oscillator and receiver on the other. The oscillator is connected to an amplifier containing carefully designed limiters that produce a square-wave voltage to be injected on one grid of a multigrid phasemeter tube. The receiver amplifier also furnishes a limited signal to the other grid of the phasemeter tube.

The phasemeter tube is by-passed by a capacitor so that fluctuations at the sound-wave frequency are removed and the fluctuations at the switching rate may be applied to a synchronized rectifier. The rectifier is actuated in synchronism with the commutator, but its active period is shorter so that harmful transients occurring during the crystal transition are suppressed.

A simple commutator, one that merely would switch the crystals alternately to the receiving and transmitting channels, is unsuitable because of the capacitive cross-coupling between the two channels. In order for the transmitted and received pulses to be absolutely representative of the separation between the crystals and the velocity of the fluid, there must be a minimum of coupling between the two channels. By very careful design of the commutator, the leakage capacitance can be reduced to about 5×10^{-6} micromicrofarads, and much of the fringe effects and ground currents is eliminated.

The rotor of the commutator is made in the form of a sandwich, consisting of two pieces of insulating material fastened to a grounded conductive shield. Two conductive segments or sectors are mounted to the insulating material but with no connection to the shield. The shield is brought out to the maximum diameter of the rotor, thereby reducing the fringe effects between the sectors. Four rows of carbon brushes are arranged so that the crystals are connected to either the receiver or oscillator for all positions of the rotor. Capacitive coupling between the sectors is reduced by maintaining a clearance of less than 0.015 inch between the sector shield and the rotor. Similarly, close-fitting shields are provided at the ends of the rotor to assist in reducing fringe effects.

The output of the phasemeter is applied to an electronic high-impedance voltmeter (which can be calibrated directly in terms of velocity) through the rectifier switch geared to the commutator drive. Fast velocity changes can be observed on the screen of a cathode-ray oscilloscope connected to the plate of the phasemeter tube. Thus, if the plate voltage is made visible, the difference between the voltages developed "upstream" and "downstream" can be used directly to estimate the flow-velocity instantaneously.

A modification to the commutation operation is the use of an electronic switch. By using vacuum tubes, the switching frequency can be increased to 1,000 cycles, for example, and the time of response can be correspondingly shortened. Four pentode amplifiers are placed between the crystals on one side and the oscillator and receiver on the other. The screen-grid supply is derived from a square-wave generator with a frequency equal to the switching rate (1,000 cycles). When the screen voltage is positive, the pentode acts as a normal amplifier; when the potential becomes negative, the electron stream in the tube is blocked and good shielding is provided. The amplifiers are so arranged that one pair operates at a time during each half of the switching cycle.

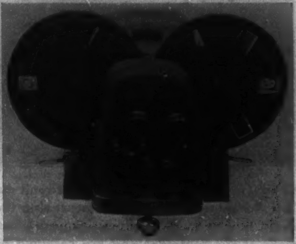
Further modifications in the flowmeter are being considered; one in particular is concerned with flow in metal pipes. A pulsed and gated phase comparison system will be used in the flowmeter for this purpose to eliminate the effects of the direct transmission of the sound through the wall of the pipe.

Mechanical switching system used in the new electronic flowmeter. The unit periodically switches the crystals from the transmitting and receiving channels at a 10-cycle-per-second rate. The rotor of the commutator (left) is made in the form of a sandwich, consisting of two pieces of insulating material fastened to a grounded conductive shield. The leakage capacitance of the commutator is reduced to about 5×10^{-5} micromicrofarads to permit a minimum of coupling between the two channels. Four rows of high-grade carbon brushes are arranged so that the crystals are connected to either the receiver or transmitter for all positions of the rotor. The compartment at the right contains the switching unit for the synchronous rectifier. The motor is geared to produce the 10-cycle-per-second switching rate

Telojector for TV Stations Projects Transparencies Automatically in Sequence

A new lightweight projector for television stations which provides automatic, remote, or local control "lapping" of an unlimited number of 2- by 2-inch transparent slides has been developed by Gray Research and Development Company, Inc.

The company developed the Telojector in co-operation with Radio Corporation of America and television engineers of other network and independent stations. There has long been a demand in the industry for foolproof low-cost equipment which would make it possible for television stations to use 2- by 2-inch (standard 35-millimeter) transparencies for commercials and other purposes. Larger, more expensive transparencies and opaque slides are used by most stations now. The problems encountered in producing such equipment have centered around: (1) the method to be used for providing an unlimited sequence of



Instantaneous fading from one slide to the next, dual projection (superimposition), and divided images can all be achieved by the Telojector

uninterrupted slides, (2) the method of providing both remote control from the control room or local control while assuring that only one slide could be tripped at a time, and (3) making the equipment so compact that it would require a minimum of space in congested television studios.

The Telojector, as can be seen in the illustration, answers the first problem by a system of dual lenses, slide apertures, and light sources. In operation, projection alternates from one lens system to the other, and the turrets which hold the slides alternately revolve one slide space as they are actuated by a solenoid mechanism.

One loading of the two turrets gives a sequence of 12 slides. Additional loaded slide turrets, which can be substituted for used turrets in a matter of seconds, provide an unlimited sequence.

Tolerances on the projection mechanism are such that the variation in positioning of successive images is well within the 1/32-inch maximum allowable. The 6-inch projection lens used provides a $4^{1}/_{2}$-inch width image on mosaic at approximately 36 inches from the slide. Other lenses may be used to provide longer focusing distances. The equipment includes infrared filters to give optimum contrast with the iconoscope film camera.

The Telojector can be used for lapping, superimposition, or divided images. It may be used through the television multiplexer or over the multiplexer with film projectors on the same camera.

Main power required for the Telojector is 115 volts, 60-cycle, alternating current. The control circuit operates from 24 volts, direct current. The 150-watt projection bulbs are long lived as they operate at reduced voltages.

Littrow-Echelle Spectrograph Embodies Major Development in Spectrum Optics

A powerful new investigative tool for use by the research or industrial physicist and chemist embodies a new concept in optics. The instrument made by Bausch and Lomb Optical Company is known as the Littrow-Echelle Spectrograph. It makes possible new advances in the study of atomic structure. In addition, it provides, in routine industrial analyses, the speedy identification and quantitative measurement of substances when they are present in the minute proportion of only one part in a million or less.

The new concept employed in the instrument deals with the properties of a new optical element known as an echelle, first conceived only 4 years ago by Dr. George R. Harrison, dean of science at Massachusetts Institute of Technology, and special consultant to Bausch and Lomb.

The echelle is the third principal development in light dispersive elements in the past 3 centuries. The other two are the prism and the diffraction grating.

Before the advent of the echelle concept, spectrographs were made constantly larger to obtain maximum utilization of prisms and gratings, until practical limitations of space blocked further progress. The echelle offers a new solution.

As used in the new instrument, an echelle is an inch-thick, optically flat glass plate, 3 inches by 5 inches, in which grooves have been precisely ground, 200 to the inch. The echelles are made by a laborious, highly skilled hand process.

Like a prism or diffraction grating, an echelle disperses light into a spectrum so that the composition of the light-emitting source can be studied in detail. The dispersive power of an echelle, however, can be 10 times or more greater than that of a diffraction grating. Its resolving power, or ability to show the separation of spectral lines, is doubled or tripled.

These properties make it possible to design high-dispersion spectrographs of smaller size than was previously possible. It would take a conventional instrument 72 feet long to approximate the dispersive power of the 8-foot-long Littrow-Echelle Spectrograph, and the larger unit would lack the light-gathering power of the echelle spectrograph.

The cover of the Littrow-Echelle Spectrograph has been raised to show the echelle (A) and the prism (B) which are so mounted as to produce a 2-dimensional spectrum of greatly increased value to scientists in exploring the structure of the atom and in making quantitative measurements of substances. By operating an electric switch, a mirror can be interposed between the prism and the echelle, thereby eliminating the latter from the optical system and converting the instrument into a prism spectrograph

In the new instrument, the echelle is used in conjunction with a prism so that the prism spreads out the spectrum horizontally on the spectrographic plate and the echelle spreads it out vertically. This produces a 2-dimensional spectrogram of greatly increased value in identifying and measuring the substances under study. This new form of spectrogram is called an "echellogram."

A typical quantitative application is the analysis for boron in steel, using the 2497.733 boron spectral line which cannot be distinguished from the 2497.820 line of iron by a conventional spectrograph. Using the new echelle spectrograph, however, these lines are readily studied because they appear 0.28 millimeter apart on the photographic plate.

A technician is shown operating the new Bausch and Lomb Littrow-Echelle Spectrograph. Light emitted by the burning sample at left is directed into the instrument and its spectrum is recorded on a photographic plate after being dispersed by an echelle and a prism

Radio Engineering Meeting to Be Held at Storrs, Conn.

The New England Radio Engineering Meeting, sponsored by the North Atlantic Region of the Institute of Radio Engineers, will be held at the University of Connecticut, Storrs, April 11, 1953. Six technical papers will be given at the sessions in the morning and afternoon. The papers are listed alphabetically by authors as the order of presentation has not been established.

Some Ancient Propagation Discoveries—Their Lessons. *Major E. H. Armstrong*, Columbia University

New Cosmotron Instrumentation. *Frederick Cowan*, Brookhaven National Laboratory

Field Tests of Compatible Color Television. *Donald Fink*, Philco Radio Corporation

TD2 Microwave Systems. *R. C. Glancy*, American Telephone and Telegraph Company

Acoustical Design Including Strategic Locations of Loudspeakers. *Robert Newman*, Massachusetts Institute of Technology

Servomechanisms. *P. M. Schultheiss*, *C. A. Wogrin*, Yale University

A-C Network Analyzer to Help Engineers Solve Power System Problems

Contracts have been signed with seven major power companies in Pennsylvania, New Jersey, and Delaware for the installation of an A-C Network Analyzer in the industrial research laboratories of The Franklin Institute, Philadelphia, Pa. The power companies—Atlantic City Electric Company, the Delaware Power and Light Company, Jersey Central Power and Light Company, Metropolitan Edison Company, New Jersey Power and Light Company, Pennsylvania Electric Company, and Philadelphia Electric Company—will use this modern computing device to help their engineers solve the many complex problems involved in maintaining and expanding power systems.

The $400,000 analyzer is being built by the Westinghouse Electric Corporation and will be installed in a specially fitted room atop The Franklin Institute. In the summer of 1954, when installation and tests are complete, the analyzer will be put to work. The seven power companies have agreed that, should they not require all the time they are allotted, they will put the device at the disposal of other utilities.

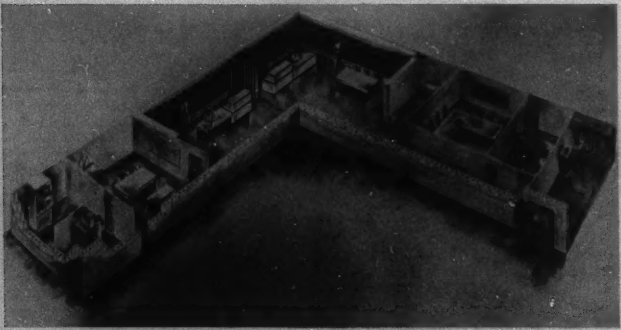
The analyzer is actually a power system in miniature, with a typical scale factor of 1 to 100,000. Its maze of circuits represents generators, transmission lines, transformers, and loads. In minutes, or hours at most, the operator can connect (by means of patch panels) these elements in imitation of any given power system. By metering current, voltage, and power at any point in the system, he can discover how the full-scale system works (or will work, if it has not yet been built), and how it might be modified to give maximum service. He will be able to solve nearly any problem concerning the design or operation of a system: transient and steady-state stability, load control, voltage regulation, relay application, and so forth.

With its 580 circuits, hundreds of relays, more than 20 miles of wire, 152 indicating instruments, the analyzer can be set up to simulate a power system that comprises as many as 28 generating stations, 270 transmission lines, 90 large blocks of load, 50 tap-changing transformers, 18 one-to-one ratio transformers, and 90 capacitors.

The first step in setting up a problem is to make a single-line diagram of the system in question, noting thereon the values of the system's components: for example, impedances are expressed in ohms or in per cent on a kilovolt-ampere base. The diagram is mounted near the instrument panel on a translucent board behind which are small lights that will indicate circuits that are being metered. Lines, transformers, current-limiting reactors, and the internal impedances of generators are represented by resistance and reactance circuits in the analyzer. Loads are represented by shunt impedances. Capacitors simulate synchronous or static condensers, and single-phase power sources, with both voltage and phase angle separately adjustable, represent generators.

When a convenient scale factor has been chosen, and after the analyzer circuits have connected to conform to the drawing, the operator employs the master instruments—a voltmeter, ammeter, and watt-var-meter—to monitor the system at whatever points he chooses. Multipliers reverse the scale of the analyzer and allow the meters to give actual values of current voltage and power.

The analyzer will incorporate 580 circuits in two separate units, one having one-third, the other two-thirds of the total capacity of the device. Each unit can operate separately or both together if the problem demands. The analyzer, conference rooms, office, storage space, power supply, and air-conditioning machinery will occupy 2,500 square feet. An operator at either one of the two instrument control desks (one with each unit) will be able to make measurements throughout the entire analyzer.



Artist's conception of what the analyzer will look like when installed in The Franklin Institute. From lower left, air-conditioning machinery and power room containing motor-generator set; conference room; area containing the smaller of the two units; larger unit (separated from the smaller by sliding partition); second conference room; office; foyer

First Large Generator Made With Liquid-Cooled Conductors

For the first time in the history of the electrical industry, the General Electric Company will manufacture a large generator with liquid-cooled conductors, using a new method of circulating a liquid through hollow conductors in the stator.

According to the *General Electric Review*, the new method of cooling will be used in a turbine-generator set for the new power plant of the Cleveland (Ohio) Electric Illuminating Company.

The unit, consisting of a tandem-compound turbine rated at 208,000 kw, and a generator rated at 260,000 kva, will be one of the largest in the world. This generator alone will be capable of supplying the household electrical needs of 600,000 people.

This type of liquid cooling makes possible a significant increase in capability of generators without increasing physical dimensions of the units. The higher capability results from more efficient removal of heat produced during the generation of electricity.

The present method of cooling large generators, by circulating hydrogen gas through passages in the magnetic portions of the rotor and stator, is highly efficient for units up to approximately 230,000-kva capability at 3,600 rpm.

Other technical features of the Cleveland machine include direct cooling of the rotating field winding with hydrogen, a new and improved grain-oriented strip steel in the magnetic portion of the armature, and an improved type of insulation.

The generator will be installed in 1955.

Challenge of Atomic Age to Men to Be Topic of Convocation

Leading American scientists will join Canadian and United States officials, prominent industrialists, and other public leaders, in a 2-day convocation in Cleveland, Ohio, April 10, 11, 1953, to discuss "The Atomic Age—Challenge to Free Men."

The convocation is to be held under the auspices of Case Institute of Technology as the first in a series of celebrations over a 3-year period marking the first 75 years of the college.

Focus for discussion of the convocation topic has been provided by President Eisenhower's declaration in his inaugural address that "Science seems ready to confer upon us, as a final gift, the power to erase human life from this planet." The challenge to science implied in that statement will be faced in the convocation discussion by a distinguished group of scientists, engineers, and industrialists.

Herbert Hoover has accepted the honorary chairmanship of the gathering and will participate in its sessions. General chairman is Charles M. White, president of Republic Steel Corporation.

The convocation will meet in six sessions.

Panel discussions will be held on the mornings and afternoons of April 10 and 11. General assemblies will be held on the evenings of both days.

The first assembly, April 10, will bring together the Honorable Clarence D. Howe, Minister for Trade, Commerce, and Defense Production of the Dominion of Canada, and Clifford F. Hood, president of the United States Steel Corporation, with George M. Humphrey, Secretary of the Treasury, as chairman. Speakers for the second evening session, April 11, are to be announced.

Grove Patterson, editor-in-chief, Toledo *Blade*, will deliver the opening address of the convocation at the first of the panel sessions on the morning of April 10. "Lifting the Burden From the Backs of Men" will be the general topic of this session. Dr. Zay Jeffries, former vice-president, General Electric Company, will be chairman of the first panel discussion. E. V. Murphree, president, Standard Oil Development Company, will discuss "Energy From Fuels," Dr. Farrington Daniels, professor of chemistry, University of Wisconsin, will speak on "Energy From the Sun" and H. A. Winne, operating vice-president, General Electric Company, on "Energy From the Atom."

"Controlling the World's Energy for Man's Tasks" will be the topic of the afternoon panel session. Dr. Vannevar Bush, president, Carnegie Institution, Washington, D. C., will preside. Speakers and their topics will be Dr. Claude E. Shannon, Bell Telephone Laboratories, "Machines that Think"; Dr. Earnest A. Hooten, Harvard University anthropologist, "The Human Animal in the Machine Age"; and Dr. Louis N. Ridenour, vice-president, International Telemeter Company, "Automization in Business and Industry."

The third panel session scheduled for the morning of April 11 will consider "Effective Utilization of Controlled Energy by Organized Society." Colonel Willard T. Chevalier, vice-president and director, McGraw-Hill Publishing Company, will be the chairman. Prominent in this discussion will be new techniques of operations research. This phase of the subject will be opened by Sir Charles Goodeve, director of the British Iron and Steel Research Association, who will speak on "Operations Research—A New Approach to Complex Social Problems." Gwilym Price, president, Westinghouse Electric Corporation, and Dr. Karl T. Compton, chairman of the board, Massachusetts Institute of Technology, will round out the panel speaking on "The Changing Nature of Management's Responsibility in Our Society" and "Social Problems and the Role of Technological Education," respectively.

The final panel discussion on the afternoon of April 11 will present Gilbert Highet, Columbia University scholar and author, as chairman of a group comprised of Cleveland's Rabbi Abba Hillel Silver, Dr. Detlev Bronk, president, Johns Hopkins University and the National Academy of Sciences, and Dr. F. S. C. Northrop, professor of philosophy and law, Yale University. The panel topic will be "Attaining Man's Hopes in the Atomic Age." Rabbi Silver's talk on "What Kind of Faith Will Serve Us Best?" Dr. Bronk's address on "Individual Dignity and Human Toil" and Dr. Northrop's on "Science and a World at Peace" will conclude the convocation's panel discussions.

Electronic Weather Prediction Urged to Cut Loss From Storms

The huge property losses, highway deaths, and the sufferings caused to millions of persons by recent ice and sleet storms in the Midwest and East, could have been greatly reduced through electronic weather prediction, according to the former top weatherman for the United States Navy.

Captain Howard T. Orville stated that radar storm-detection units, co-ordinated with other key equipment placed at about 35 points in the nation, could predict to the minute both the arrival of a storm and its duration, as well as its intensity.

Captain Orville, who was the first in the Navy to advance the concept of radar tracking of hurricanes, which has cut deaths from these storms by 98 per cent, said it would cost about $5,000,000 a year for 10 years to set up this nation-wide electronic weather-warning system, but that the end result would be savings of billions in storm damage and thousands of lives.

Equipment for each of the 35 electronic weather stations would include: 1. Storm-detection radar to give an instantaneous "picture" of all rain, snow, sleet, or hail over an area of several thousand square miles from the station. 2. Radar cloud-base and cloud-top recorders to provide continuous information on cloud layers passing over the station. 3. Upper-air weather recording equipment such as "Radiosonde" balloons which automatically radio back to earth data on temperature, pressure, humidity, and other facts from altitudes up to 100,000 feet. 4. Radar and television units to relay "pictures" of weather conditions from one station to another. 5. Electronic computers to combine the data from the station with other facts gathered from Weather Bureau observation points throughout the Northern Hemisphere.

In some conditions, Captain Orville added, radar-equipped aircraft would be used to supplement the ground units. Each station would be manned by 10 or 12 weather observers and two radar technicians.

Dr. Gustav Egloff Receives The Washington Award for 1953

Dr. Gustav Egloff, petroleum scientist and director of research for Universal Oil Products Company, Des Plaines, Ill., was presented with engineering's foremost honor, The Washington Award for 1953, on February 23, 1953.

The presentation was made by Ovid W. Esbach, president of the Western Society of Engineers and dean of the Technological Institute of Northwestern University.

The Washington Award is an honor conferred by five national engineering societies upon an outstanding engineer for accomplishments which pre-eminently promote the happiness, comfort, and well-being of humanity.

Dr. Egloff is being honored "for distinguished leadership in petroleum research and development in professional activities and in community services."

Dr. Gustav Egloff (left) receives The Washington Award for 1953 from Dr. O. W. Eshbach (right) on February 23, 1953, in Chicago, Ill.

This latest tribute to Dr. Egloff's genius comes on top of more than a score of honors he has received from America and 34 foreign countries. He holds more than 300 patents on inventions covering the processing of oil, coal, shale, and the chemical derivatives of hydrocarbons.

He is one of the world's foremost authorities on petroleum, and is the author of more than 600 articles and 11 books relating to this field.

In receiving the Washington Award, Dr. Egloff joins an imposing list of world-famous personages who have been so honored. These include Herbert Hoover in 1919; Orville Wright, 1927; Charles Kettering, 1936; Ralph Budd, 1941; Henry Ford, 1944; Arthur Compton, 1945; Vannevar Bush, 1946; Karl Compton, 1947; Wilfred Sykes, 1950, and Dr. Henry Heald, 1952.

The Washington Award is based on recommendation of a commission representing the American Society of Civil Engineers, AIEE, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the Western Society of Engineers.

Endeavour Prizes Announced by British Science Association

As a contribution to the meeting of the British Association for the Advancement of Science to be held in Liverpool, England, on September 2–9, 1953, Imperial Chemical Industries, Ltd., publishers of the quarterly scientific review, *Endeavour*, have offered the sum of 100 guineas to be awarded as prizes for essays submitted on a scientific subject.

As the primary purpose of these awards is to stimulate younger scientists to take an interest in the work of the British Association and to raise the literary standard of scientific writing, the competition is restricted to those whose 25th birthday falls on or after June 1, 1953.

Five prizes will be awarded: A first prize of 50 guineas (approximately $147); a second prize of 25 guineas (approximately $74); a third prize of 15 guineas (approximately $44); and two special prizes of 5 guineas (approximately $15) for competitors who have not passed their 18th birthday on June 1, 1953.

The subjects for the essays are as follows: radio-astronomy; color and chemistry; biology in world affairs; science and safety in transport; science and art; scientific con-

Mobile Substation Unit

This vehicle is the New Hampshire Electric Company's new mobile substation unit, one of the most modern in existence. It has a rated capacity of 2,000 kva and is specially designed to meet the varying voltage requirements of the company's territory, which covers 34 towns in New Hampshire and Maine

tributions to medicine; scientific societies and their role; and power and civilization. The essays, which must be in English and typewritten, should not exceed 4,000 words in length, and only one entry is permitted from each competitor.

All entries should be addressed to: The Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W. 1, England, and the envelope should be clearly marked *Endeavour* Prize Essay. The latest date for receipt of entries is June 1, 1953. The essays will be judged by the editors of *Endeavour* in consultation with representatives of the British Association. The successful competitors will be invited to attend the whole of the Liverpool meeting, at which the prizes will be presented, and their expenses within the United Kingdom will be paid. The judges' decision is final and they reserve the right to withhold all or any of the prizes should no entries of sufficient merit be received.

The essays should be submitted without signature. The competitor's full name and address and date of birth should be disclosed in a sealed covering letter attached to the essay and addressed to the Assistant Secretary of the British Association, who will acknowledge all entries. The names will not be disclosed to the judges until after the prize-winning essays have been selected.

In judging the results special attention will be paid to the originality of the approach to the subject, and great importance will be attached to literary style. The competitor's age will be taken into account also. The essay winning the first prize will be published in *Advancement of Science*, journal of the British Association.

Addenda. Engineers desiring more information on the National Bureau of Engineering Registration (*see article, EE, Feb '53, p 184*) should contact T. Keith Legare, Executive Secretary, National Bureau of Engineering Registration, The National Council of State Boards of Engineer Examiners, P. O. Drawer 1404, Columbia, S. C.

Device Helps Pilot Evaluate Airport Approach Lights

Fog at airports constitutes a serious hazard to air traffic. Although extensive flight tests have been made to determine which of many proposed approach-light systems is best suited for landing in fog, these tests have thus far failed to bring about agreement on any one system. To supply this need, the National Bureau of Standards (NBS), in co-operation with the Navy Bureau of Aeronautics, has developed a device known as the kinorama with which a pilot can evaluate the guidance provided by a system of approach lights without leaving the ground. Perhaps more important in the long range than determining the best approach-light system will be the use of the kinorama in providing pilots with the vital training for landing in fog which now can be acquired only through hazardous experience.

The use of the kinorama makes it possible for the pilot to see an approach-light configuration speeding by him just as he would in flying over it in fog. The course followed in such a simulated flight is determined by the pilot himself, who acts in response to the lights that are visible to him. By recording the paths thus followed, it is possible to obtain objective records reflecting the merits of the light system. While the device is not a substitute for flight testing for the final approval of a system, it is inexpensive, objective, free from hazards, and not dependent upon the occurrence of fog.

In spite of the excellent electronic equipment which has been developed for guiding pilots in fog, safe landings in bad visibility are not yet a common practice because there remains the problem of making the final contact with the runway. Where so much is at stake, it is desirable, if possible, to make this final contact visually rather than to trust the operation of electronic devices. It is the purpose of the approach lights to furnish an earlier visual contact with the ground.

Many engineers and pilots have attempted to design systems of lights to guide pilots in the critical seventeen seconds between the time the aircraft is near enough to the ground to be within the reach of lights and pilot's first sight of the runway lighting. Practically all discussion of the merits of these different systems has revolved about stationary aspects of their designs, such as the interpretation of geometrical figures, the visual range of the lights, and the possibility of seeing lights in different locations. It is quite evident, however, that approach lights cannot be seen in stationary arrangements by pilots except in the unusual cases of fixed balloons and helicopters.

Two devices which incorporate the natural apparent motions of landing aircraft have been developed for the study of approach-light systems. One of these, called the cyclorama, has been used for some time for demonstrations in England. This device, however, is limited to configurations in a single plane and hence cannot be used for evaluating a 3-dimensional arrangement of lights such as the slope-line system. The second device, the NBS kinorama, undertakes a more complete simulation than the cyclorama and includes the 3-dimensional aspects of approach-light systems.

Two models of the kinorama have been constructed at the National Bureau of Standards under the direction of F. C. Breckenridge. After the original experimental or laboratory model had demonstrated that it is possible to achieve the desired flight simulations, an improved prototype kinorama was constructed.

The basic principle of the kinorama is to represent an approach lighting system by a small, movable model whose motions are the reciprocal of those which an airplane would have in landing over the lighting system. Because the pilot's reaction is the true test of any system being evaluated, the motions of the model must be those which would normally appear to follow the pilot's use of his controls. In the kinorama, the approach lights are represented by fluorescent miniatures of lighting units mounted on an endless tape which moves continuously toward the observer, simulating the plane's forward motion over the approach and runway lights. For lighting systems comprised of units that are all in one plane, it is only necessary to represent the lights by small spots of fluorescent material on the surface of the tape. However, for systems like the slope-line system in which the third dimension is significant the lighting units are represented by miniatures which include the third dimension.

To simulate the lighting system on a sufficiently small scale so that over-all dimensions are kept within practical limits, the point of observation must be placed very near to the tape in order to make the view correspond to that from points along the approach path. This is accomplished by the use of a telescope with negligible magnification and an objective approximately 0.5 inch in diameter. With a larger objective, it would not be feasible to bring the point of observation sufficiently near the lighting units and only the first stages of an approach could be simulated. With a telescope of sufficient length the pilot can sit in his seat normally and see the lights as if he were coming down among them. The telescope also simplified the problem of simulated banking. It was only necessary to install a dove prism at a suitable location in the telescope and rotate this prism to obtain a realistic simulation of a lighting system as seen from a banking plane.

The laboratory model is built on the fuselage of an airplane with its associated instruments and controls. Hinged plywood platforms, which move relative to one another, provide the apparent motions of flight. In the prototype kinorama, the cockpit, instruments, and controls of a Link trainer take the place of those of the airplane and the plywood platforms are replaced by rectangular frames of aluminum alloy. A true vertical motion has been substituted for the hinged movement. All the angular motions are simulated optically which simplified the mechanical design and made it possible to provide the desired yaw movements with less width. Servomotors control all movements of the kinorama including a recorder which provides a permanent record of each "landing." Special equipment allows automatic presetting of any one of nine initial landing states—that is, the selection of one of nine combinations of three altitudes with three transverse positions, combined with a predetermined yaw, bank, and pitch for each state. This flexibility of presetting is sufficient to meet the needs of a wide variety of landing problems.

Evaluation of three different types of visual aids has been undertaken with the kinorama: (1) a comparison of three "over-run" lighting systems designed at Wright-Patterson Air Force Base, utilizing different types of lighting units; (2) a comparison of the three approach-light systems proposed for standardization by the International Civil Aviation Organization; and (3) a study of longitudinal and transverse markings for runways.

In addition to its usefulness for evaluating lighting systems the kinorama gives promise of being a valuable training device. The use of approach-light systems in good weather does not make a pilot proficient in using them in fog. The irregularity and suddenness with which fogs occur, on the other hand, make it impracticable for a pilot to obtain his training by gradually flying in more and more difficult weather. The kinorama can be used to supplement experience in landings with moderately low ceilings and prepare a pilot for landings in actual fog. This will make it possible for pilots to complete landings with approach lights when the weather has deteriorated and thus obviate the inconvenience of having passengers diverted to alternate landing fields at some distance from their destination.

Cadmium Sulfide Crystal Acts as High-Speed Level Checker

A tiny crystal of cadmium sulfide, about the size of a match-head, acting on signals from an 80,000-volt X-ray tube, is now doing a "watchdog" job for several major brewers, insuring automatically that all cans of beer are tightly sealed and contain exact measure.

Known as a high-speed level checker, the unit is capable of inspecting cans or cartons at rates far greater than those at which any processing line presently operates, and can work at and above a speed of 900 containers per minute within an accuracy of 30 drops of beer or ±1/64 inch.

In addition to beer, the unit can be adapted to inspecting many products packed in cans or cartons, including such liquids as milk, fruit juices, waxes, oils, and chemicals; such grains as salt, cereals, and soaps; and powders, such as flour, bake mixes, insecticides, and tooth powders.

The brewers using the new unit term it a "sleepless eye," which performs a needed job that has been impossible hitherto. It unfailingly spots low-fill, indicating leaky cans, and can be adapted also to checking overfill, which leads to excessive gas pressure.

The crystal detector is placed at the desired height of fill level on one side of the conveyor line, with the X-ray tube on the other. When a can or carton that is not full enough comes along, the crystal receives an extra jolt X ray from the tube, which changes it from a nonconductor to a very good conductor of electricity and starts an electric circuit in operation. This is relayed to an automatic air-blast unit, which blows the faulty container off the line.

This apparatus is the "last word" on the inspection line, being placed at the conveyor just before the cans are loaded into cartons.

All-Electric Pumping Station to Increase City's Water Supply

The new Thomas H. Allen Pumping Station of Memphis, Tenn., will increase the city's existing water supply by 50 per cent.

Expected to be completed in 1953, the new all-electric station will supply 30,000,000 gallons of water a day to meet the ever-expanding demands of increased water consumption per capita and the rapid growth of population in the city. The General Electric Company is supplying the major share of the electric equipment for the station which will hydraulically parallel the existing Parkway and Sheahan Stations, both steam-operated.

Since the water distribution system of Memphis is a "closed" system with no elevated storage, the maintenance of adequate and even pressure necessitates continuous pumping at a rate equal to water use.

To prevent outages under normal emergencies, the pumping station will have four separate sources of power, three of which will be capable of handling the entire station load separately. Normally, power will be supplied through a single 12,000-volt line and cable from a near-by substation. Two additional 12,000-volt lines originating at a steam-driven generating station will furnish emergency circuits. A diesel-driven electric generator which can supply one-third of the station's power requirements will be available in the event all other sources fail. Suitable controls will transfer the station to emergency sources automatically.

Four 600-horsepower wound-rotor motors will be used as prime movers for the De Laval pumps which will maintain a constant discharge head of 166 feet.

General Electric 12-kv switchgear will be installed to handle the incoming 12,000-volt power supply lines. Two lineups of 2,400-volt "double-bus–double-breaker" switchgear will be used to furnish power for the pump motors.

Except for emergency operation when the diesel generator is employed, the entire station can be operated from a benchboard in a centrally-located control room. This concentration of all controls will make it possible to operate the pumping section of the station with one operator per shift. Obviously, additional personnel for maintenance and emergencies will be required.

The benchboard will be divided into three functional sections with the left end controlling the well pumps, the right end controlling and providing supervision of the station valves, and the center section controlling the power sources and the station pump motors.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Proposed Symbols and Terms

To the Editor:

An AIEE committee report entitled "Proposed Symbols and Terms for Feedback Control Systems" was published in the October 1951 issue of *Electrical Engineering* (*pp* 905–09). The AIEE Standards Committee has received a criticism to the effect that publication of this report in *Electrical Engineering* appears to have given it unofficial status as a standard, whereas a committee of another organization does not agree to some of the terms and nomenclature proposed in the report.

Such reports are often published to obtain wider consideration which will assist in making desired revisions and in obtaining final agreement. The AIEE Standards Committee takes this occasion to point out that the subject report was not submitted to the Standards Committee for approval and does not have the status of a standards publication authorized by the AIEE Standards Committee and published as a Standard, Recommended Practice, or Report.

MERWIN BRANDON (F '44)

(Chairman, AIEE Standards Committee; Underwriters' Laboratories, Inc., New York, N. Y.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PRINCIPLES OF VOLTAGE REGULATION. With Reference to Generation and Transmission of Electric Energy. By B. B. Ray. Thacker Spink and Company, Ltd., Calcutta, India, 1950. 269 pages, diagrams, charts, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound. 15 rupees. A comprehensive survey of automatic voltage regulation in electrical generation and distribution from the simple vibrating contact type of regulator to the present-day practice of amplidyne and electronic type of apparatus. The author deals, from a practical standpoint, with the problem of voltage control of mercury-arc rectifiers, automatic tap changers, feeder voltage regulators, and the recent development of normally inactive regulators for control of large generators. The theory and calculation for design of a system which the author has included will be of interest, and the problem of light flickering receives special consideration.

THEORY OF ELECTRIC POLARIZATION. By C. J. F. Böttcher. Elsevier Publishing Company, 402 Lovett Boulevard, Houston, Tex., 1952. 492 pages, tables, charts, 9 by $6^{1}/_{4}$ inches, bound. $10. In this book the theory of electrical polarization and related subjects are extensively discussed in an unconventional but highly detailed manner. Beginning with a fundamental discussion of electric dipoles, the author goes on to multipoles, the relation of polarization and energy, polar and nonpolar dielectrics, polarization at optical frequencies and at high frequencies, and the polarization of solids. Intended for advanced students, the thorough mathematical treatment includes four appendixes on specialized mathematical operations.

THERMIONIC VACUUM TUBES. By W. H. Aldous and Sir Edward Appleton. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., sixth edition, 1952. 160 pages, diagrams, charts, $6^{3}/_{4}$ by $4^{1}/_{4}$ inches, bound. $2. A selective account of the internal action of modern thermionic tubes and their behavior in various typical applications in physics and electrical communication. Separate chapters are devoted to the use of tubes as amplifiers, rectifiers, frequency changers, and oscillation generators, to the miscellaneous uses of feedback, and to certain special applications. The treatment is designed to be suitable for the student of general physics who has not made a special study of radio-frequency phenomena.

WATER SUPPLY AND PURIFICATION. By W. A. Hardenbergh. Laurel Publishers, Scranton 9, Pa., third edition, 1952. 516 pages, charts, diagrams, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, bound. $6.50. The theories underlying the collection, transportation, delivery, and treatment of water are presented, including the determination of quantity of water available, pipe-line calculations, design of distribution systems, and purification processes. In addition to the general revision throughout the book, new material has been added on such developments as fluoridation, and on planning for emergencies and civil defense with the available information on bacteriological and radiological warfare. Actual problems are used for illustrative purposes.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

ELECTROCHEMICAL DATA. By B. E. Conway. Elsevier Publishing Company, 402 Lovett Boulevard, Houston, Tex., 1952. 374 pages, tables, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8.75. This work provides detailed tabular information on aspects of electrochemistry for which exact data of known accuracy are available. Besides information on pure electrochemistry—electrode potentials, solvation, and ionic interaction in aqueous and nonaqueous solutions—data have been included on quantitative aspects of applied electrochemistry: on slags and fused melts; and on applications in the field of biophysics. Explanatory introductions to chapters are included, and extensive references to original information sources are given.

ÉQUIPEMENT THERMIQUE DES USINES GÉNÉRATRICES D'ÉNERGIE ÉLECTRIQUE. By J. Ricard. Dunod, Paris, France, second edition, 1948, new printing 1953. 658 pages, charts, diagrams, tables, $9^{3}/_{4}$ by $6^{3}/_{4}$ inches, bound. Ffrs 4,400.—A thorough, over-all treatment of the thermal equipment of steam plants for generating electricity. It covers steam cycles, heat transfer and heat exchangers, fuels and combustion, steam boilers, boiler furnaces, combustion calculations, feedwater treatment, combustion control, steam turbines, condensers, and other auxiliary equipment. Separate chapters are devoted to special topics such as the economics of steam generation, interconnected plants, standby plants and accumulators, and the selection of steam cycle and equipment. There is a bibliography.

THE EXPLORATION OF SPACE. By Arthur C. Clarke. Harper and Brothers, 49 East 33d Street, New York, N. Y., 1951. 199 pages, diagrams, illustrations, $8^{1}/_{4}$ by $5^{3}/_{4}$ inches, bound. $3.50. Written to answer the questions of the intelligent layman, this book provides a nontechnical but scientifically accurate treatment of the field of "astronautics." It deals with rocket propulsion, escape velocities, the requirements of a spaceship, refueling stations in free orbit around the earth, and space navigation. It describes briefly the characteristics of the moon (including a hypothetical lunar base), the inner and outer planets, and other possible solar systems. Consideration is given to the engineering, medical, and physical problems connected with space travel, and its possible significance to civilization is discussed.

MAJOR FAULTS ON POWER SYSTEMS. (Monographs on Electrical Engineering, Volume XIII). By A. G. Lyle. Chapman and Hall Ltd., London, W. C. 2, England, 1952. 355 pages, illustrations, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 45s. This monograph, written by an authority in the field of electric power supply, is a critical examination of the behavior of power systems under fault conditions, and should prove especially useful to practicing engineers. The author investigates the origins, the effects, and the magnitudes of currents and voltages of lightning and switching surges, and some of the phenomena associated with failures of insulation. At the same time, protective equipment such as surge arresters, absorbers, suppressors, relay systems, and circuit breakers are discussed. Some representative problems are worked out in the text, and the results of field tests are given in appendixes.

NIEDERDRUCK-STROMRICHTERVENTILE. By Hans von Bertele. Springer-Verlag, Vienna, Austria, 1952. 239 pages, charts, diagrams, illustrations, tables, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $9.30. After a discussion of the physical phenomena involved, particularly in mercury-arc rectifiers, the characteristics of the individual structural types of low-pressure rectifiers are developed, with a simple graphical method for calculating output capacity and optimal operating conditions. Stress is laid on the influence and importance of the selection of materials and vacuum technology. The theoretical deductions are supported by practical examples. The detailed treatment includes the development from the beginning of the century to the most modern thyratrons, ignitrons, and excited single-anode rectifiers.

ATMOSPHERIC POLLUTION. Its Origins and Prevention. By Æ. R. Meetham. Pergamon Press Ltd., London, England, 1952. 268 pages, charts, diagrams, illustrations, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, bound. 35s. This book treats the whole subject of fuel pollution in Great Britain—principally in the forms of sulphur dioxide, smoke, and ash. It goes into the subjects of fuels, fuel-burning appliances, and industrial processes, besides giving information on the measurement, distribution, and effects of atmospheric pollution. Remedial measures are also considered, together with some legislative measures in England and the antismoke laws in the United States. The nontechnical approach of this book renders it useful to a variety of interested groups.

ELECTRICITY METERS AND INSTRUMENT TRANSFORMERS. By S. James. Chapman and Hall Ltd., London, England, 1952. 467 pages, charts, diagrams, illustrations, tables, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 50s. A comprehensive treatment of practical meter work by an engineer directly connected with the manufacture of meters. Detailed descriptions are given of the construction and operation of a wide variety of d-c, single-phase a-c, and polyphase a-c meters. Chapters are devoted to prepayment meters, maximum-demand indicators, and summation metering, and to current and voltage transformers. Basic theory and metering practice and economics are included, but meter testing has been omitted. It is to be covered in a companion volume.

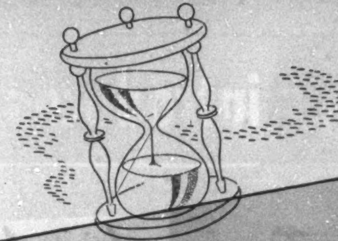
FILTER DESIGN DATA FOR COMMUNICATION ENGINEERS. By J. H. Mole. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 252 pages, charts, diagrams, tables, 10 by $6^{1}/_{2}$ inches, bound. $7.50. Intended for the practical designer, this book provides an extensive compilation of charts, tables, and formulas to facilitate the necessary calculations and to supplement the existing textbooks on theoretical principles. The explanatory text stresses design methods and the use of the charts and formulas, with no derivations except where they clarify the presentation. The book is concerned mainly with the Zobel filter, although the last chapter is devoted to design on a general basis of certain simpler filters, also applicable to transformer design. An elementary knowledge of the principles of line transmission and filters is assumed.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

United Nations Statistical Yearbook. *Statistical Yearbook 1952* is a comprehensive collection of international statistics presented in 177 tables relating to demographic, economic, financial, social, and cultural subjects and covering in most cases the two decades ending 1951 or early 1952 Of especial interest are tables on the output of electric energy, showing the rapid and widespread expansion in output. Other data are included on consumption of energy, world fuels and energy, and iron and steel production. The Yearbook also contains production data for a large number of mineral and manufactured products. 554 pages. $7.50 cloth bound; $6.00 paper bound. Obtainable from the Columbia University Press, International Documents Service, 2960 Broadway, New York 27, N. Y.

Television Recording Project. To meet the need for recording apparatus suitable for storing televised information for application to military operations, a study has been made of the elements of a suitable recording system. In this report are discussed the factors dictating the choice of video-amplifier characteristics, camera-television signal synchronization, recording rate, and possible future alternatives to the present film recording technique. 31 pages. $1.00. Available from Office of Technical Services, United States Department of Commerce, Washington 25, D. C.



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"...picked for the job," says Clarence, "because of Locke's success with similar projects...and because of its extensive research, test and manufacturing facilities."

"Rarely," says Clarence, "has a manufacturer of electrical porcelain insulators been assigned a job as unusual and exacting as that of designing and building this big, complicated antenna lead-in bushing. To the best of my knowledge," he says, "it's the only bushing of its size and type in existence."

As Clarence tells the story, "Since nothing like it had ever been built before, plenty of original research and development work was required."

"However," says Clarence, "special assignments involving extensive research never seem to bother us. Our big advantage is the fact that our insulation research, test and manufacturing facilities are among the world's finest and largest."

"These facilities give us the tools with which we can lick the toughest kind of problems in porcelain engineering."

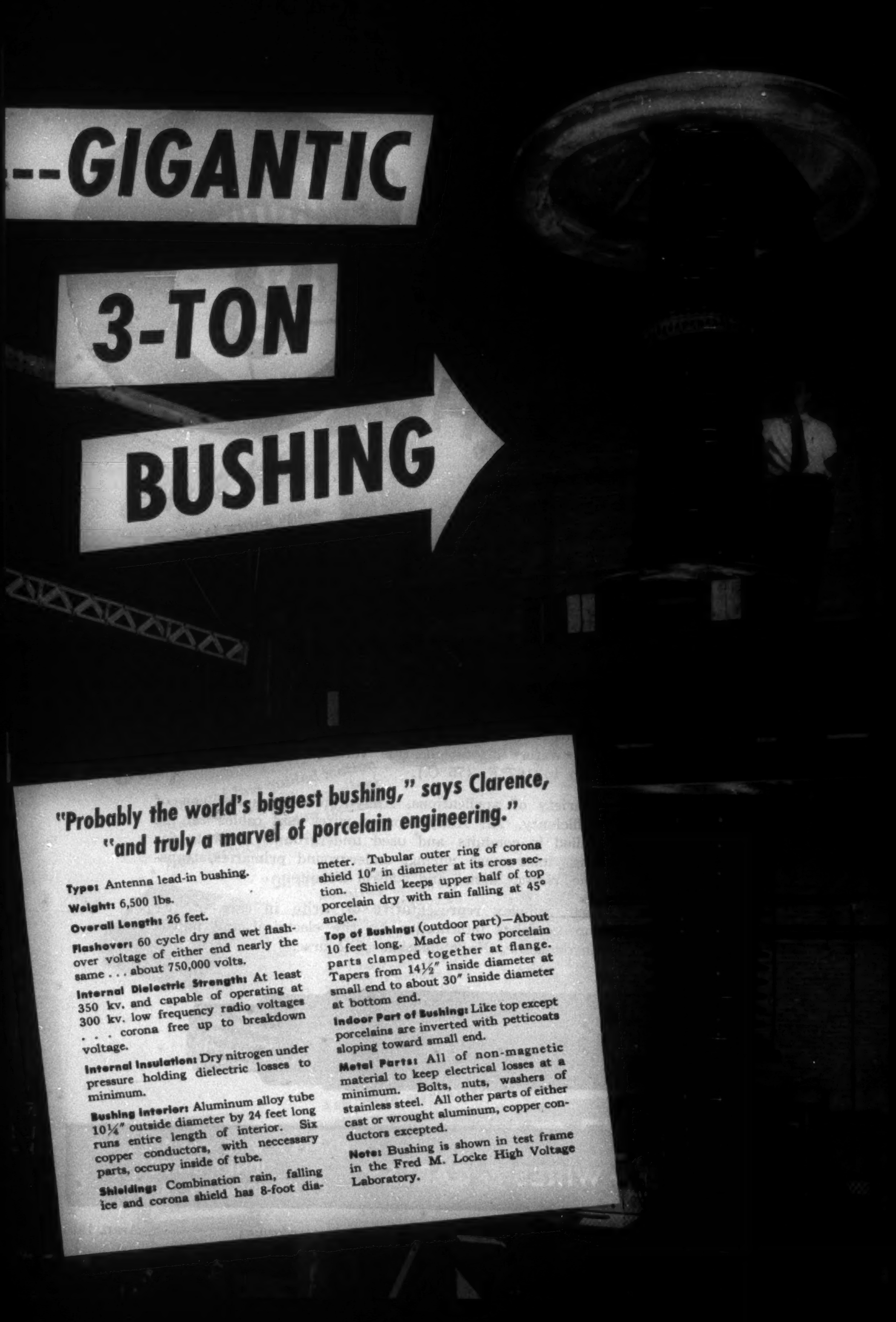
"Our success with special projects like this," says Clarence, "must be comforting to users of Locke Suspension, Switch, and Pin Type insulators. As I see it, a fellow can relax when he knows that the same skills, facilities and experience which produced this bushing . . . are always at work building reliable performance into the Locke insulators already on his lines, or on order."

"Leading utilities seem to feel that way about it," observes Clarence. "Judging by the number of insulators going out of here every year, you get the impression that utilities have practically unlimited confidence in Locke insulators. And," adds Clarence, "this confidence is well placed. Utility Service records prove it."

LOCKE

LOCKE DEPARTMENT
GENERAL ELECTRIC COMPANY
BALTIMORE, MARYLAND

Vol. 72
1953



"Probably the world's biggest bushing," says Clarence, "and truly a marvel of porcelain engineering."

Type: Antenna lead-in bushing.

Weight: 6,500 lbs.

Overall Length: 26 feet.

Flashover: 60 cycle dry and wet flashover voltage of either end nearly the same . . . about 750,000 volts.

Internal Dielectric Strength: At least 350 kv. and capable of operating at 300 kv. low frequency radio voltages . . . corona free up to breakdown voltage.

Internal Insulation: Dry nitrogen under pressure holding dielectric losses to minimum.

Bushing Interior: Aluminum alloy tube 10¼" outside diameter by 24 feet long runs entire length of interior. Six copper conductors, with neccessary parts, occupy inside of tube.

Shielding: Combination rain, falling ice and corona shield has 8-foot diameter. Tubular outer ring of corona shield 10" in diameter at its cross section. Shield keeps upper half of top porcelain dry with rain falling at 45° angle.

Top of Bushing: (outdoor part)—About 10 feet long. Made of two porcelain parts clamped together at flange. Tapers from 14½" inside diameter at small end to about 30" inside diameter at bottom end.

Indoor Part of Bushing: Like top except porcelains are inverted with petticoats sloping toward small end.

Metal Parts: All of non-magnetic material to keep electrical losses at a minimum. Bolts, nuts, washers of stainless steel. All other parts of either cast or wrought aluminum, copper conductors excepted.

Note: Bushing is shown in test frame in the Fred M. Locke High Voltage Laboratory.

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You can't be too particular what kind of wire and cable you buy. Lack of quality invites trouble. Trouble that brings unnecessary shutdowns, rising costs, and lower production rates. Why then get substitutes when you can install Simplex-Anhydroprene, the top quality wire and cable that assures you of longer-life and trouble-saving service.

Anhydroprene construction consists of a solid or stranded coated conductor, Anhydrex insulation, and a thin neoprene jacket. Light in weight and small in diameter, it is easy to handle and terminate. Anhydroprene resists oil, grease, corrosive chemicals, light and flame. With a high dielectric strength and low water absorption, this versatile wire operates at copper temperatures up to 167°F. (75°C.).

Designed for a variety of applications, Anhydroprene assures you of increased operating efficiency. All Anhydroprene wires and cables can be racked on walls, installed in conduits and used underground in ducts for plant and shop wiring, instrument wiring, underground primaries, transformer leads, pole line risers, signal and control circuits.

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Specify SQUARE D Motor Starters for 3 Important Reasons

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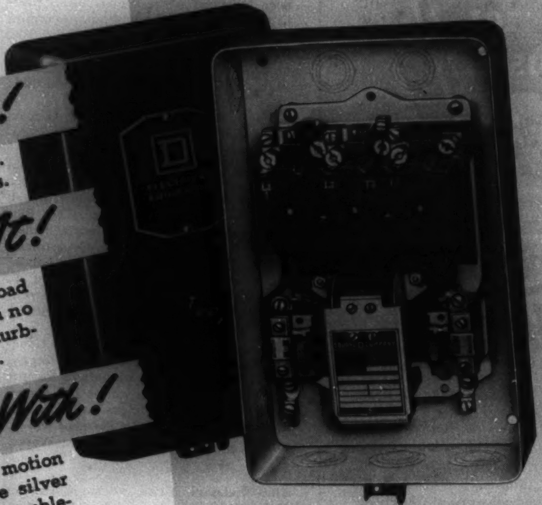

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Straight line guided motion minimizes wear; large silver alloy contacts insure trouble-free electrical performance.

"Off-the-Shelf" Parts Kits make normal maintenance easier than ever. Each kit contains parts necessary to replace all load contacts and finger springs. An illustrated service bulletin is enclosed to provide quick parts identification and complete installation instructions.

ELECTRICAL INTERLOCKS are available in kit form. Practically any necessary number or arrangement of extra interlock contacts can be added to any standard starter. Sizes 2 and 3 starters have new front-of-panel mounting interlocks for faster, easier installation.
(See cutaway at left)

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INDUSTRIAL NOTES ....

General Electric Notes. Retirement of H. Herbert Magdsick, for the past 23 years executive engineer in the Application Engineering Department of General Electric's Lamp Division at Nela Park, Cleveland, Ohio, has been announced. Mr. Magdsick's retirement follows more than 42 years of service with the company.

Leland D. Whitescarver has been appointed Manager of Marketing for the Medium Steam Turbine, Generator and Gear Department in Schenectady, N. Y.

A $400,000 modernization program has been launched at the Bleeker Street plant in Utica, N. Y. The program, according to the plant manager, Frank Greene, Jr., will involve the installation of machinery to be used in the manufacture of Polystyrene cabinets for clock radios and table model radios.

The Small and Medium Motor Department has been discontinued and its operation has been decentralized into three new product organizations. A divisional marketing department also was established to facilitate a unified approach to all division marketing policies. The four new departmental organizations and their managers are: Marketing Department, Walker H. Henry, manager; Medium Induction Motor Department, Olaf F. Vea, general manager; Direct Current Motor and Generator Planning Study, Oscar L. Dunn, manager; and Synchronous and Specialty Motor and Generator Department, Fred B. Hornby, general manager. Headquarters for the first three organizations will be at Schenectady, and the Synchronous and Specialty Motor and Generator Department will be located at the Lynn (Mass.) River Works.

Allis-Chalmers News. Appointment of Arthur F. Erwin and Edward F. Brill as manager and chief engineer, respectively, of Allis-Chalmers atomic power section in Milwaukee, Wis., has been announced. Mr. Erwin joined Allis-Chalmers in 1935 and has been assistant manager of the atomic power section since 1951. Mr. Brill has been associated with the company since 1941 and in 1949 was transferred to the atomic power section and in 1952 was named engineer-in-charge.

J. T. Graham, a resident representative in the Jacksonville, Fla., office of Allis-Chalmers general machinery division since 1948, has been advanced to manager there. At the same time it was announced by D. S. Kerr, manager of the company's Southeast Region, that Jacksonville is now a branch office of the Tampa district.

William L. Manly, for the last several years special assistant to C. W. Schweers, vice-president and director of sales at the General Machinery Division in Milwaukee, Wis., has been named assistant director of sales of the division.

New RCA Appointment. Election of L. W. Teegarden as executive vice-president of the Radio Corporation of America has been announced. Mr. Teegarden, a pioneer merchandiser, has been active in the electrical and electronics industries for many years. Prior to assuming his new post, Mr. Teegarden was vice-president in charge of Technical Products of the RCA Victor Division. In this position, he supervised the activities of both the Engineering Products Department and of the Tube Department.

Westinghouse News. Carroll B. Dick has been appointed manager of the Westinghouse Electric Micarta Division. Mr. Dick, formerly works manager of the Westinghouse Electric Appliance Division plant at East Springfield, Mass., will succeed E. R. Perry, who has resigned to accept a position with an eastern firm.

P. C. Smith, manager of the Transportation and Generator Division at East Pittsburgh, Pa., has appointed W. R. Sugg, Jr., assistant manager of the Division, and G. A. Moore, manager of manufacturing.

Appointment of two Westinghouse Electronic Tube Division sales executives to newly created sales posts was announced. John J. Doyle, a 25-year man with Westinghouse, assumes the new post of manager of renewal tube sales, and James L. Brown, a veteran of 16 years' electronic tube sales experience, becomes manager of equipment tube sales.

Electric Service Manufacturing Personnel Changes. Warren Erbe, St. Louis, Mo., sales representative for Electric Service Manufacturing Company, has been named district manager of that office.

Ray Gawthrop, of the Philadelphia, Pa., office has been transferred to the Detroit, Mich., office.

Research Organization Formed. Olin Industries, Inc., has announced the formation of a general research organization that will conduct basic research and work with all eight Olin manufacturing divisions on long-range and specialized research problems and will co-ordinate the efforts of the company's various divisional research departments. Laboratories already have been established at New Haven, Conn., and East Alton, Ill., staffed by a total of 45 scientists. Dr. Herman Bruson, one of the country's top Polymer chemists and holder of 280 separate United States patents on chemical products and processes, has been named head of Organic Chemical Research.

America Lava Notes. The American Lava Corporation, Chattanooga, Tenn., announced the election of G. E. Richter as vice-president–Director of Sales, and the appointments of James L. Ridkin as Sales Manager, Eastern Division, and

(*Continued on page 22A*)

Vol. 72
1953

YOUR SWITCH and BUS INSULATORS
NEVER HAVE TO TAKE THIS PUNISHMENT

. . . but they can if they're made of

VICTOR PURIFIED PORCELAIN

VICTOR
PURIFIED PORCELAIN
1953

Left: Victor No. 729 Stacking Unit undergoing cantilever test to determine ultimate strength.

It's pretty satisfying to know that the insulators on your system can take more punishment than they'll ever get in service. That's why more and more power men specify Victor *Purified Porcelain* insulators. Laboratory tests show they have unequalled cantilever, torsion, tension, and compression strength, perfection of glaze and durability under all service conditions. For complete engineering data, send for Bulletin No. 5.

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SWITCH and
BUS INSULATOR

FREE BOOKLET gives you the full story on how Victor insulators are made . . . how and why *Purified Porcelain* was developed. Write us for your copy.

Specify

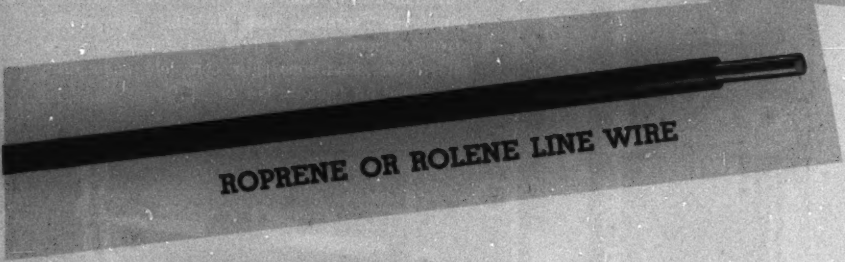
VICTOR INSULATORS, INC., VICTOR, N. Y.

Low and High Voltage Pintypes • Suspensions • Guy Strains • Spools • Switch and Bus Insulators • Custom Designed Porcelain

You get these advantages with

Rome Aluminum

ROPRENE SELF-SUPPORTING SERVICE DROP CABLE


ROPRENE OR ROLENE LINE WIRE

3 BIG REASONS...

Why you are bound to save money with Rome Aluminum Self-Supporting Service Drop Cable and Rome Aluminum Line Wire . . . lower purchase cost . . . lower installation costs . . . longer service life.

Lower purchase cost... Depending upon the service involved, aluminum conductors cost less today.

Lower installation costs... Aluminum's lighter weight means easier and cheaper handling . . . in many instances permits longer spans with fewer poles. The simplicity of Rome's Self-Supporting Cable construction means increased savings through cheaper hardware and ease of installation.

Longer service life... Aluminum has proved itself as a long-life conductor material. RoPrene (Neoprene) as well as RoLene (polyethylene) as either insulation or covering has exceptional resistance to sunlight, moisture, corrosive atmospheres and abrasion. With no braids to rot and festoon, replacement is minimized.

Rome Aluminum Self-Supporting Service Drop Cable is regularly supplied with two RoPrene (Neoprene) insulated power conductors of solid aluminum, spiralled around a bare neutral messenger of ACSR (aluminum conductor steel reinforced). This time-proven construction provides high strength, simplicity of installation.

Rome Aluminum Line Wire is available with covering of RoPrene (Neoprene) or RoLene (polyethylene) as specified. Here is low cost Line Wire having ease of handling, as well as long, non-festooning service life. Uniformly small diameters provide neater appearance, plus reduced wind and ice loading.

It Costs Less to Buy the Best

Rome

ALUMINUM

ROME CABLE CORPORATION, ROME, N.Y., AND TORRANCE, CALIF.

REGOHM
ERROR SIGNAL
POWER AMPLIFYING
SYSTEM STABILIZING
IMPEDANCE MATCHING
CONTROLLED DEVICE
OUTPUT MEASUREMENT

7 Reasons why Regohm is a natural for your control system

This compact, electro-mechanical controller provides sensitivity, speed of response and system stabilization under severe operating conditions. Its design and operating features have made Regohm useful for automatic control systems in which heavier, more expensive and complex, but less accurate equipment had previously been the only available solution.

① **SMALL SIZE** · Regohm is a compact, plug-in device; lightweight, extremely rugged and position-free. The unit's small size does not limit its power-handling capacity. This makes Regohm a "natural" where economy of space and weight are your major considerations.

② **POWER AMPLIFYING** · Regohm is a high-gain electro-mechanical power amplifier. Milliwatt variations in signal energy can control energy changes millions of times greater.

③ **IMPEDANCE MATCHING** · Signal and controlled circuits are isolated, both electrically and structurally. Signal coils may have ratings from 0.01 to 350 amperes. Controlled resistors on a panel in which Regohm is plugged, can have values from zero to infinity, depending on the controlled system.

④ **SYSTEM STABILIZING** · A thoroughly reliable, sturdy dashpot aids in system damping. It can easily and readily be adjusted over a wide range to match the dynamic characteristics of the Regohm to those of your present system.

⑤ **ANALYTICALLY DEFINABLE** · The response of Regohm is independent of the rest of the servo system. Its response characteristic can be expressed in terms of conventional "transfer functions." Regohm acts as an integrating error-rate proportional controller. No appreciable steady-state error can occur. Regohm's effect can be calculated in advance, simplifying the design and facilitating the prediction of performance.

⑥ **CONTINUOUS CONTROL** · In "closed loop" systems a high-speed averaging effect occurs as Regohm's armature oscillates over a small amplitude. This provides intermediate values between step resistances and results in continuous, stepless control in systems operating at power frequencies and below.

⑦ **LONG LIFE** · In properly engineered installations, Regohm's life is measured in years. Plug-in feature simplifies replacement and maintenance—there are no parts to renew or lubricate. Shelf life is substantially unlimited.

Our engineering and research facilities can help you apply Regohm to your servo system or regulator problem. Write for Bulletin 505.00, analyzing Regohm's characteristics and applications. Address Dept. EN, ELECTRIC REGULATOR CORPORATION, *Norwalk, Connecticut.*

REGOHM

CONTROL COMPONENT IN: Servo systems • battery chargers • airborne controls • portable and stationary generators • marine radar • inverters • locomotive braking systems • mobile telephones • guided missiles • signal and alarm systems • telephone central station equipment • magnetic clutches • railroad communication systems.

(Continued from page 18A)

E. Dudley Bell as Sales Manager, Western Division.

A new Syracuse, N. Y., office has been opened at 330 Arlington Avenue, Syracuse 7. Gilbert Reimann is their representative in charge.

New Appointment. The Board of Directors of Rickard and Company, Inc., has announced the election of Howard H. Sharman as executive vice-president.

NEW PRODUCTS • •

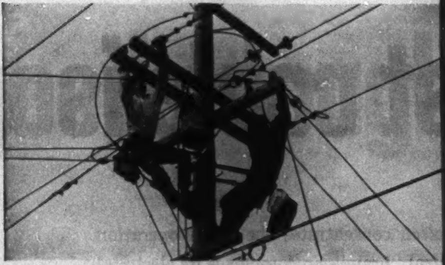
Meter for Testing Secondary Voltages. A way to test accurately the secondary voltage of synchros and other circuits requiring meter-current corrections is provided by the model *105* Meter Matcher. It is a highly accurate power frequency amplifier. When used in conjunction with a voltmeter or wattmeter, it practically eliminates the errors previously caused by meter currents. In a typical application, the secondary voltage of synchros under test varies from 40 to 90 volts. A 1/4-per-cent accuracy electrodynamometer voltmeter with a resistance of approximately 3,000 ohms is used. To prevent loading the synchro, at least 100,000 ohms must be across the secondary, hence the Meter Matcher. Its input is connected to the synchro, its output to the voltmeter. Input impedance of the Meter Matcher requires less than 150 microamperes from the test circuit. Its output provides the 0.05 to 0.07 ampere which most accurate dynamometer instruments require for full-scale deflection. Connections for 15-, 75-, 150-, 300-, and 600-volt inputs are provided, with an output of 150 volts in each case. This gives a 150-volt voltmeter or wattmeter an effective range of full-scale voltages from 15 to 600 volts. Over-all accuracy of the Meter Matcher is such that less than 0.15-per-cent error is added to measurements. In addition to the testing of synchros, the amplifier has numerous uses where exceptional accuracy is required. These include measuring both linear and nonlinear circuits when meter currents introduce errors not easily computed, increasing meter sensitivities, and as a signal amplifier. Full details on request to Keithley Instruments, 3868 Carnegie Avenue, Cleveland 15, Ohio.

Sudden-Pressure Relay. A new sudden-pressure relay that protects power transformers from internal faults is available from the Westinghouse Electric Corporation. Operating on rate of change of pressure, it is not affected by pressure changes common to transformer operation. In addition, it is more sensitive to small faults, and is quicker to operate when large faults occur than were previous pressure devices. When an arc breaks

(Continued on page 28A)

MAKE IT GOOD
WITH ALUMINUM CONDUCTOR

PROVED FOR SERVICE—Rapidly increasing usage of aluminum conductor for service drops, secondary and transmission lines is proof of its industry-wide acceptance. Proof that aluminum conductor is doing a good job under widely varied conditions.



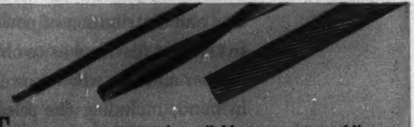
PROVED FOR CONVENIENCE—Aluminum conductor's natural advantage of light weight makes it the first choice of many linemen. Aluminum strings faster, easier—saves installation time and money.

PROVED FOR SAVINGS—You get important savings *automatically* when you specify aluminum conductor. The initial cost of aluminum is far less than with copper. And easier handling is possible because of aluminum's light weight.

MAKE IT BETTER
WITH KAISER ALUMINUM CONDUCTOR

FIELD SERVICE—Kaiser Aluminum field men have a growing reputation for helping make better installations at lower cost. They pitch in and help on a job, use their long experience to devise cost-cutting techniques. They closely watch schedules to insure on-time delivery of Kaiser Aluminum conductor.

ENGINEERING AND LABORATORY SERVICE—Specialists from Kaiser Aluminum Engineering Service are available for meetings with supervisors and crews—often resulting in worthwhile savings, improved installations. Sag and tension charts are provided where necessary. Research problems are carefully studied by Kaiser Aluminum Laboratory Service—one of the best-staffed and best-equipped in the industry.



THIS COMPLETE SERVICE is available to you at no obligation when you specify Kaiser Aluminum conductor. *Act now!* Request free pamphlet giving complete engineering data on new Kaiser Aluminum covered conductor—both weatherproof line wire and self-supporting Triplex cable for service drops and secondary distribution lines. Contact any Kaiser Aluminum office in principal cities, or one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc., Oakland 12, California.

Kaiser Aluminum

setting the pace—in growth, quality and service

Neoprene and Polyethylene Covered Conductor, Solid and Stranded
Self-supporting Triplex Cable • ACSR • All Aluminum Conductor

General view of turbine hall in a recently constructed municipal power plant.

Only the best cable is

MODERN engineering practice often concentrates the entire operation of a power station in one central "brain". So complex is its electrical system that control cables of the finest quality are imperative.

On these pages is shown the panel which completely controls the generation and distribution of power in a typical modern central station. The idea in this installation was to obtain the maximum reliability for the generating station and the whole power system. Everything has been done with this in mind, including the selection of OKOLITE-OKOPRENE throughout.

Shown inside the rear housing of the main control and relay panels in the detail view are the many 600-volt color-coded cables that provide all interconnections for control, metering, indicator, interlock and alarm circuits. The wiring originates in the switch-gear on the balcony floor,

OKONITE SINCE 1878 ***insulated cables . .***

Rear of main control and relay panels showing Okolite-Okoprene control cables.

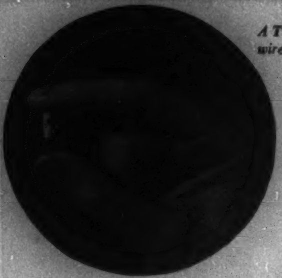
good enough for this job

at the secondary terminals of the potential and current transformers and terminates at the control panel.

Wherever rugged operating conditions are found, wherever service requires that outages be kept to a minimum, electrical engineers for over 75 years have been specifying Okonite cables. They take advantage of the Okonite program of constant research to provide more dependable cables. They know Okonite's exclusive strip process . . . how the insulation and sheath are applied simultaneously and vulcanized *only once* in a metal mold, assuring perfectly centered conductors, a more stable and longer-lived insulation and sheath. For further information on OKOLITE-OKOPRENE cables, write for BULLETIN EG-1056. The Okonite Co. Passaic, New Jersey.

products of on-the-job experience

1551



*A **Transistor** of point-contact type. Two hair-thin wires control current flow in germanium metal.*

It's helping to win the Battle of the Watts

*Laboratories engineer examines **Transistor** oscillator. It is used in Englewood, New Jersey, where 10,000 subscribers can personally dial distant cities. **Transistors** generate the signals which carry the dialed numbers to other towns and cities. Other uses are in prospect.*

When you keep down the power needed to send voices by telephone you keep down the special equipment needed to supply that power. A great new power saver for telephony is the ***Transistor***, invented at Bell Telephone Laboratories, and now entering telephone service for the first time.

Tiny, simple and rugged, the ***Transistor*** can do many of the things the vacuum tube can do, but it is not a vacuum tube. It works on an entirely new principle and uses much less power than even the smallest tubes. This will mean smaller and cheaper power equipment, and the use of ***Transistors*** at many points in the telephone system where other equipment has not been able to do the job as economically.

It's another example of how Bell Telephone Laboratories makes basic discoveries, then applies them to improve telephone service while helping to keep its cost down.

TRANSISTOR FACTS

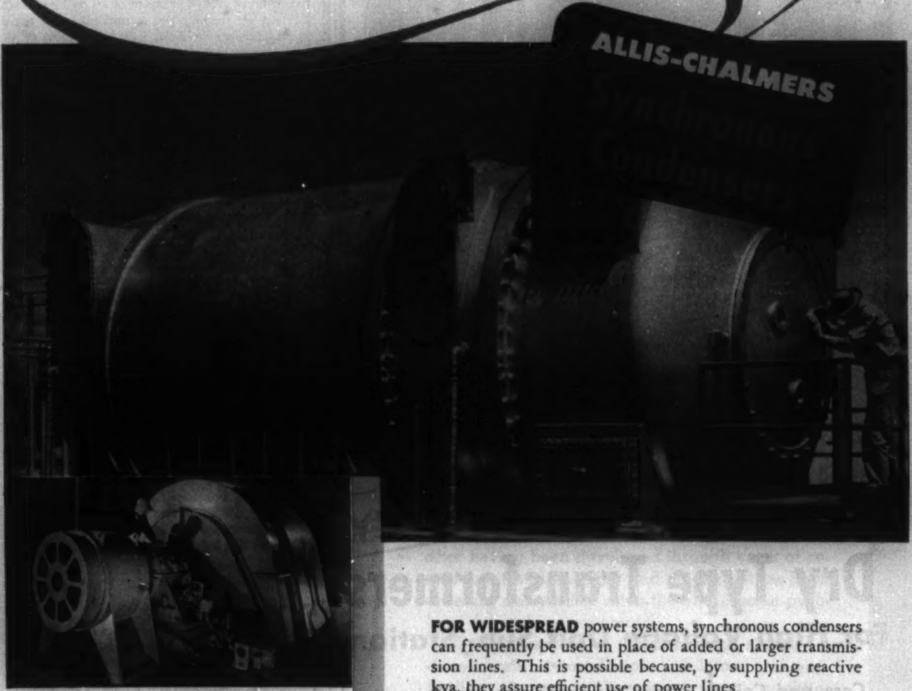
Created by Bell scientists. First announced in 1948.

Has no glass bulb, requires no filament current or warm-up period. Operates instantly when called upon. Uses no energy when idle.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields.

Better than Rebuilding Transmission Lines



Pacific Coast system uses 50,000-kva hydrogen-cooled condenser (top view), and 20,000-kva air-cooled unit (bottom view).

Besides minimizing losses, hydrogen cooling results in a design suited to outdoor operation. Air-cooled units can also be built for outdoor use, and for industrial power-factor-correction applications.

Regulex amplifier control, which acts as both regulator and pilot exciter, is available for all synchronous condenser ratings.

Regulex is an Allis-Chalmers trademark.

FOR WIDESPREAD power systems, synchronous condensers can frequently be used in place of added or larger transmission lines. This is possible because, by supplying reactive kva, they assure efficient use of power lines.

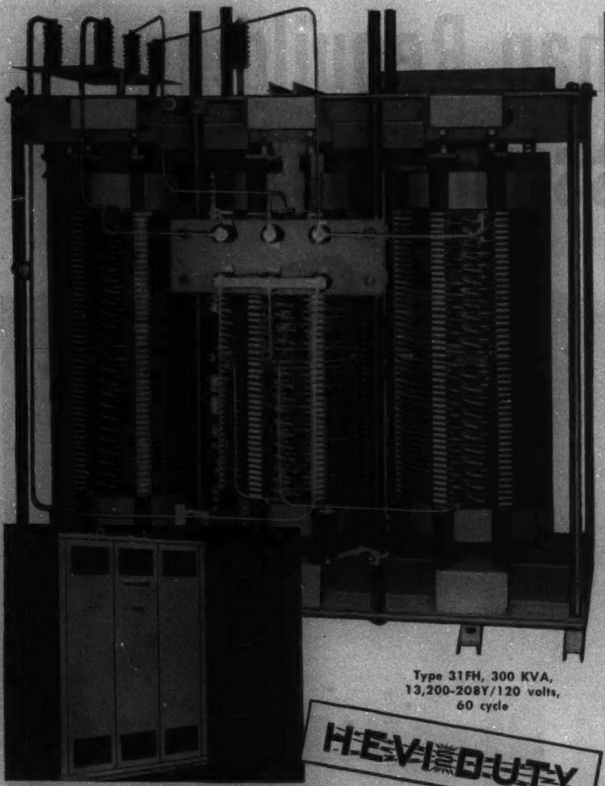
But condensers can do more than just cut conductor requirements. They also provide voltage regulation on a wholesale scale, and furnish rotating inertia for improved system stability.

Custom-engineered to fill system requirements and to fit installation conditions, Allis-Chalmers synchronous condensers can help you hold down transmission costs. For more information on units for utility or industrial applications, call in your A-C representative, or write for Bulletin 05B7285. Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3960

A-C ALLIS-CHALMERS

ALLIS-CHALMERS



Type 31FH, 300 KVA, 13,200-208Y/120 volts, 60 cycle

HEVI DUTY

Dry Type Transformers

For High Voltage Unit Sub-Stations

Core and Coil Assembly can be supplied separately or as a Unit Sub-Station complete with primary and secondary switchgear according to your specifications.

Hevi Duty Transformers are designed and built to offer that extra protection needed during peak operating periods. Note the adequate core and coil blocking, high voltage insulators and well ventilated pancake type coils on the transformer shown here.

Specify Hevi Duty Transformers in your unit sub-station and you assure yourself of dependable service.

Let our engineering staff design a transformer to meet your specifications.

Write for Bulletin HD-499

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces . . . Electric Exclusively
Dry Type Transformers Constant Current Regulators

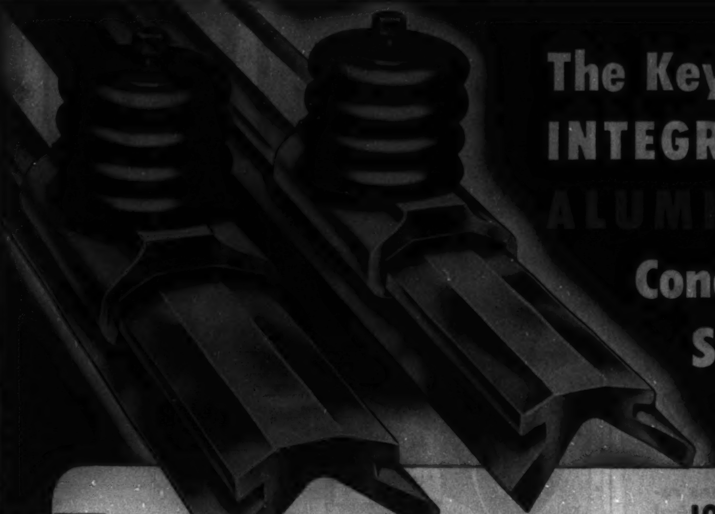
(*Continued from page 22A*)

down transformer oil, the increased gas pressure is transmitted from the transformer case to the relay device through a small tube. The pressure differential is throttled through the tube and actuates a bellows that is sensitive to a rate of rise of pressure as low as approximately 1 ounce per square inch per second. A microswitch connected to the bellows either will sound an alarm or trip a circuit breaker to take the transformer out of service. A manually operated momentary off switch is provided to reset the relay. Faults that produce rates of rise of pressure of 10 to 15 pounds per square inch per second cause the relay to operate in 2 or 3 cycles. Rates of 40 pounds per square inch per second cause operation within 1/2 cycle. For further information, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh, Pa.

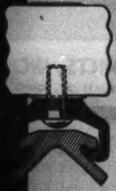
Float Switch. The Revere float switch was designed originally as an aircraft high-level fuel-control instrument, providing automatic cutoff control for single-point high-pressure fueling and air-to-air refueling. It is suited also for many industrial applications where fluid level control is important. The instrument is available in many different configurations, some of which include relays to handle heavy electric loads. Others are designed for complete submersion in fluids. The Revere float switches can be supplied with single level or dual level systems. Each system provides an electric signal through a magnetically operated switch, which is hermetically sealed in a glass tube. The actuating alnico magnet is incorporated in the counter weight of a statically balanced float assembly. The actuating magnet, positioned by the float, opens or closes the switch at predetermined levels which are set precisely at the factory. For complete information write Revere Corporation of America, Department 60, Wallingford, Conn.

Comparison Bridge. Accurate and simple production tests are possible on the new general-purpose type *1604-A* comparison bridge developed by General Radio Company, Cambridge, Mass. With a basic accuracy of 0.1 per cent, the bridge can be used for direct comparison of resistors, capacitors, and inductors over the wide impedance range of about 2 ohms to 20 megohms. Two impedance-deviation ranges, ±5 per cent and ±20 per cent, are provided. Dissipation-factor or storage-factor differences are indicated also. The bridge is completely self-contained with a cathode-ray visual detector and an oscillator operating at either 1 kc or 5 kc. Operation is from the a-c line. The point at which the bridge is grounded can be switched, so that measurements can be made with the unknown either grounded or ungrounded. The primary application for the comparison bridge is that of sorting components to a given tolerance. The standard to be used need not be a precision standard

(*Continued on page 34A*)

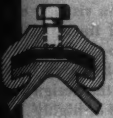


The Keystone INTEGRATED ALUMINUM* Conductor System



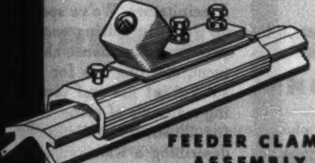
HANGER SECTION

Conductor free to slide within support, allowing for expansion and contraction.



JOINT PLATE AND BOND ASSEMBLY

Non-loosening spring-type splice plate provides excellent electrical and mechanical joint characteristics between conductor sections.



FEEDER CLAMP ASSEMBLY

features a bimetal separator that eliminates galvanic corrosion between copper terminal and aluminum surface, providing foolproof, long-lasting connection.

LOWER COST

LIGHTER WEIGHT, HIGHER EFFICIENCY

SAFER ENCLOSURES

An integrated power supply system designed to complement the best materials handling equipment—1000 amperes capacity for heavy duty systems . . . economical for use on control circuits.

The Keystone Aluminum Conductor System is now being employed in outstanding installations, after having been developed through years of research in the laboratory and industry. It has been carefully designed to solve the troublesome problems formerly encountered.

The light weight of this conductor system reduces costs of installation, insulators and supporting structures. Its non-corrosive qualities permit use on sensitive control circuits. Longer contact life. Compact design saves space, permits better protection. All components are pre-fabricated. Available complete with brackets and enclosures. No copper boosters nor priorities needed. Easily engineered, installed and maintained.

*Domestic and Foreign Patents Pending

Write today for new, illustrated 4-page folder on Keystone Integrated Aluminum Conductor System.

ELECTRIC SERVICE MANUFACTURING CO.

PHILADELPHIA 32, PENNA

SILVER GRAPHALLOY

BRUSHES

AND

CONTACTS

. . . for applications requiring low electrical noise, low and constant contact drop, high current density and minimum wear.

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.

EXTENSIVELY USED IN

SELSYNS
ROTATING THERMOCOUPLE and
STRAIN-GAGE CIRCUITS
ROTATING JOINTS
GUN-FIRE CONTROLS
DYNAMOTORS etc.

Wide range of grades available for standard and special applications.

Brush holders and coin silver slip rings available for use with Silver Graphalloy Brushes.

OTHER GRAPHALLOY PRODUCTS:

Oil-free self-lubricating Bushings and Bearings, Oil-free Piston Rings, Seal Rings, Thrust and Friction Washers, Pump Vanes.

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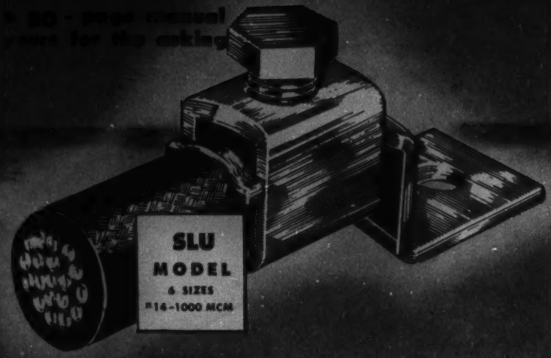

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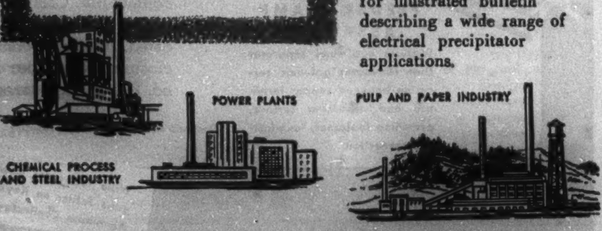
Industry looks to
RESEARCH
CORPORATION
for high
dust collection
efficiencies

To maintain visually clean stacks at all times, industry is turning to the long experience of Research Corporation in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.



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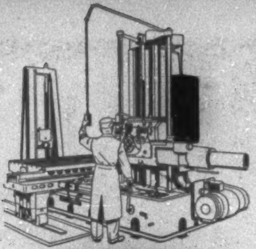
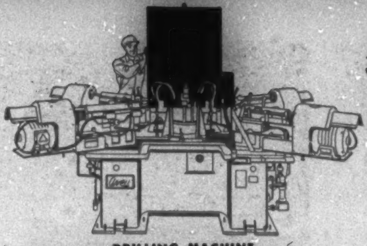
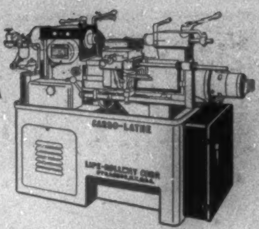


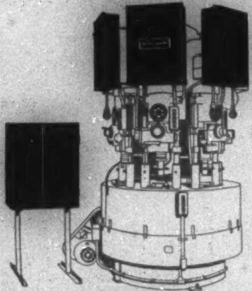
HORIZONTAL BORER



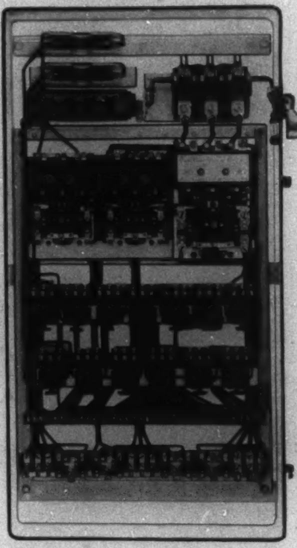
DRILLING MACHINE



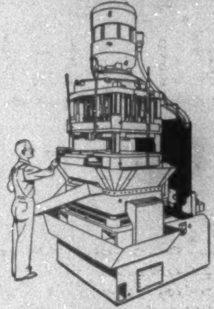
CARBO LATHE



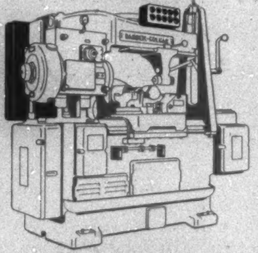
TURRET-HONE



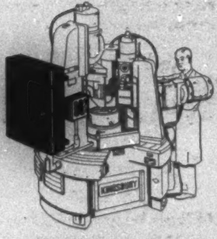
Typical machine tool control panel showing disconnect unit, contactors, and accessories



DRILL



HOBBING MACHINE



TAPPING MACHINE

MACHINE TOOL CONTROL PANELS

• • • ENGINEERED TO SATISFY YOUR NEEDS

Allen-Bradley control panels are popular with machine tool builders, because—

1—A-B contactors and relays have acquired a worldwide reputation for dependability and precision control. Consistently, they perform millions of trouble free switching operations.

2—A-B engineers, through long experience, are skilled in developing sequence control panels. Due to the compact design of A-B components, smaller panels are a common result . . . which means less space is used on the machines.

3—The A-B trademark is a sales asset for your motorized machine tools. It is the mark of Quality in motor control . . . known and accepted by machinery buyers, everywhere.

It will pay you to discuss your control problems with Allen-Bradley. A field force of Allen-Bradley engineers, located in all principal cities, is at your service. We shall be glad to send you the A-B Handy Catalog.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

4-53-R

A-B
Quality

ALLEN-BRADLEY
QUALITY

SPECIAL PANELS

A-C & D-C TROUBLE FREE RELAYS

from 1 to 12 POLES

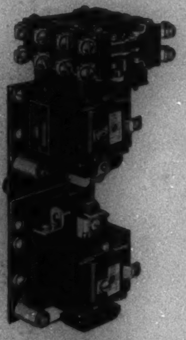
THE UTMOST IN RELAY DEPENDABILITY

HUM-FREE A-C RELAYS

Relays in hospitals, churches, etc., must be hum-free. For these places, Types BM and BXL relays are recommended. Continuous coil currents are not needed to hold them closed. Also useful for machine tools.

TYPE BM—Residual Magnetic Latch

Contacts are held closed by residual magnetism of core. A demagnetizing coil current opens relay.



TYPE BXL—Mechanical Latch 2-Unit Relay

Lower solenoid trips the mechanical latch of the upper relay to open the upper relay contacts.

Bulletin 700 Relays are built to the same critical operating standards as the larger switching units in the Allen-Bradley line.

They have only one moving part . . . the simple solenoid plunger that opens and closes the double break, silver alloy contacts. Available in many varieties of contact arrangements . . . up to 12 poles . . . with or without enclosures. Long, trouble free life makes these relays the ideal pilot controls for installations which are likely to get infrequent inspection and maintenance.

Send for Bulletin 700 containing complete details on ratings, dimensions, and related accessories.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY

RELAYS & CONTACTORS

A-B
Quality

TYPICAL RELAYS in the ALLEN-BRADLEY LINE

Relay in Enclosure

6 Pole A-C Relay

3-Wire Thermostat Relay

Low Current A-C Relay

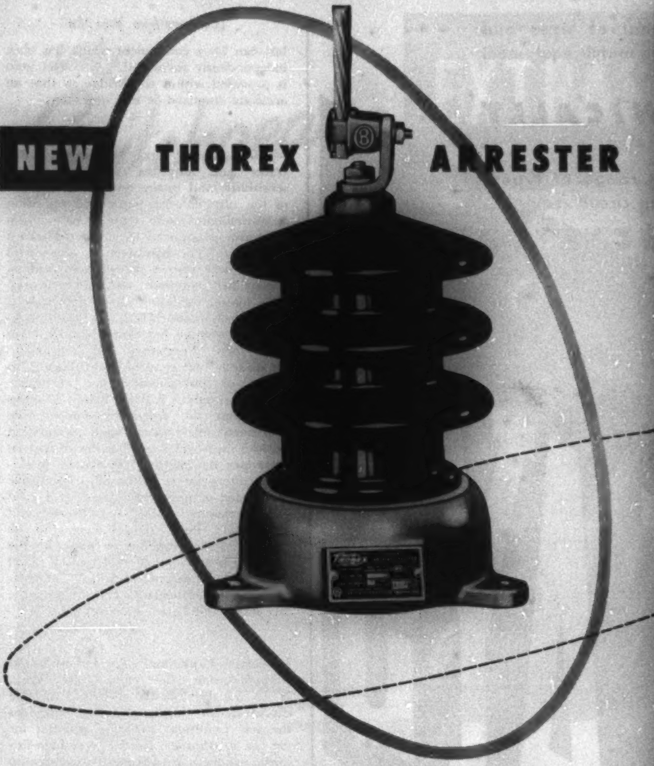
D-C Relay

Bulletin 709 Size 3 Solenoid Contactor

4-53-A

Vol. 72
1953

NEW THOREX ARRESTER



for close-clearance mounting!

Retaining all of the excellent protective characteristics of the Type GP Thorex lightning arrester, the new GPA Model permits a radical reduction of mounting clearance dimensions. This makes for easier installation in the confined spaces of unit substations or other restricted enclosures. When mounted indoors within enclosed switch gear, this arrester may be installed in upright, horizontal, or inverted position, thus permitting full advantage to be taken of its close spacing possibilities. Universally adjustable terminals allow for any direction of lead.

Restricted clearance in the new Thorex GPA is obtained by all-porcelain top construction, where the energized element is confined to a small central stud and terminal, thus gaining over six inches of radius when compared to the arrester employing a top casting energized at line potential.

Another improvement in the new Type GPA Thorex is a closer graduation of line-to-ground, power frequency voltage ratings. This arrester is now available in 3, 4.5, 6, 7.5, 9, 12 and 15-kv values.

Other than clearance, the Model GPA is identical to the metal-top Thorex line -- offering you a high level of lightning protection at low cost.

Ohio Brass
MANSFIELD OHIO, U.S.A.

4386-H

✓ Largest assortment of sizes and mounting styles to match equipment requirements

MECHANICALLY

✓ Widest range of types t
exacting circuit requi
ELECT

S-D
STRUTHERS-DUNN, INC.

RELAYS

5,348 TYPES

STRUTHERS-DUNN

STRUTHERS-DUNN, INC., 150 N. 13th ST., PHILADELPHIA 7, PA.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES
MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(*Continued from page 28A*)

but can be a component which has been independently measured. An offset zero is provided within the bridge so that an accurate standard is not necessary.

Multipurpose Signal Generator. Receiver and amplifier gain, selectivity, sensitivity, and image rejection are a few of the ultrahigh-frequency and television measurements made with a new signal generator announced by Hewlett-Packard Company. The equipment is also useful as a power source for driving bridges, slotted lines, antennas, and filter networks. This master oscillator power generator is designated model *612A*. It offers continuous coverage between 450 and 1,200 megacycles. Frequency and output are set directly and read on large dials. No charts or interpolation are necessary. Maximum output is 0.5 volt into 50 ohms throughout the frequency range. The instrument offers broad-band modulation up to 5 megacycles and has low incidental frequency modulation. It can be modulated internally or externally, amplitude modulated or pulse modulated with good radio-frequency pulses 0.2 microsecond or longer. Pulse modulation may be applied to the amplifier or direct to the oscillator section when high on-off signal ratios are desired. For further information, write Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif.

Miniature Capacitor. The Hammarlund Manufacturing Company, New York, N. Y., has developed a miniature variable capacitor, type *MAC*. The *MAC* provides the low minimum capacity essential for use as a trimmer in the very-high-frequency range. Its silicone-treated steatite base is only 3/4 inch by 5/8 inch. The rotor and stator are soldered assemblies of brass which are later silver plated for low losses. A silver-plated beryllium-copper wiper rotor contact is used. Rotor and stator terminals are positioned to permit short leads. The threaded bearing is provided with flat sides to permit single hole mounting without turning. The new units are available to fulfill capacity requirements between 1.4 and 19.6 micromicrofarads.

Recorder Amplifier. A new electronic device, the model *R3* recorder amplifier, has been developed at the Goodyear Aircraft Corporation, Akron, Ohio. The amplifier is a lightweight portable unit designed especially to plot the solutions to small problems where the use of a large recorder would be impractical. The *R3* works with standard direct-inking or hot-wire recording galvanometers. Its accuracy is limited only by the nonlinearities of the galvanometers. Typical units are guaranted to be within 2 to 5 per cent. The *R3* records two channels of information within a frequency range essentially flat from direct current to 100 cycles. The amplifier unit supplies its own power and has its own voltage regulator. Ampli-

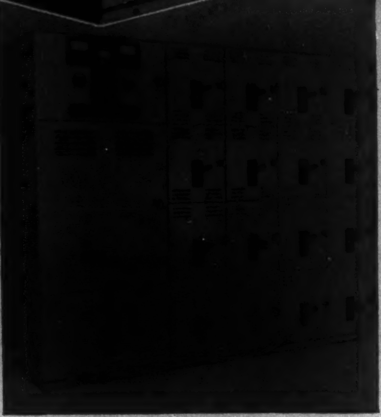
(*Continued on page 52A*)

in Switchgear...

EXTRAS COUNT!

Specify ROLLER SMITH

Get *all the extras*
Roller-Smith switchgear provides . . .
extras in Safety, Accessibility and Economy of operation.



- **SAFE** All equipment is metal enclosed . . . weather proofed when required . . . built to NEMA and AIEE standards for safe, dependable performance. The "up-to-the-minute" design of Roller-Smith switchgear assures *extra* safety for operators.

- **ACCESSIBLE** All sections of RS switchgear are easily accessible for quick inspection and adjustment. This cuts maintenance time to a minimum . . . makes it easier to do a thorough job.

- **ECONOMICAL** All Roller-Smith equipment is precision-built according to your specifications . . . tested *before* you get it. When you specify Roller-Smith, you can count on *extra* long, trouble-free operation with less "down time" for repairs.

Consult your nearest Roller-Smith representative, or write to us for catalogs which fully illustrate and describe our complete line of low voltage draw-out; moderate duty, vertical lift Metal Clad; and heavy duty Metal Clad switchgear.

ROLLER SMITH

ROLLER-SMITH CORPORATION
Bethlehem, Pennsylvania

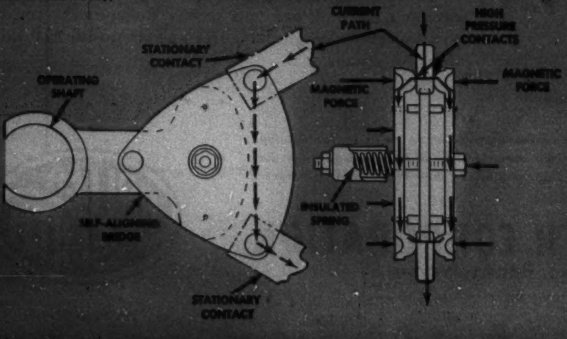
Gives You Outstanding POWER On

Voltage Stresses Reduced

Illustration shows moving contact member bridging stationary tap lead connections. By keeping sharp edges to minimum, voltage stresses are reduced.

Simple Maintenance

Tap changer is mounted above core and coil assembly. Inspection through cover manholes is easy. Tap positions change in all phases simultaneously.


CURRENT PATH
HIGH PRESSURE CONTACTS
STATIONARY CONTACT
MAGNETIC FORCE
OPERATING SHAFT
MAGNETIC FORCE
INSULATED SPRING
SELF-ALIGNING BRIDGE
STATIONARY CONTACT

How It Works

A positive flow path is established under high unit pressure by a round point on a flat contact surface. High unit pressure promotes low contact resistance, deters heating.

Parallel plates form movable contact bridge. Magnetic forces that are set up as a result of the flow of parallel currents in the bridge prevent "throw open" when a short circuit occurs.

Get the illustrated data sheet with all the details from your nearest A-C office or write Allis-Chalmers, Milwaukee 1, Wis.

Performance

the Line”

What power transformer is best for your system? This decision is difficult — transformers may look alike, have standardized ratings and specifications. Yet, there is *one big variable* — QUALITY — that *extra* measure of value which means better continuity of service.

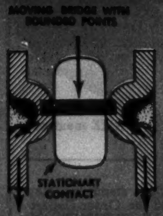
For over a half century Allis-Chalmers has been earning the approval of utility men who say A-C transformers give outstanding performance. You can depend on Allis-Chalmers design, construction and attention to details because experience proves you get the most advanced, the most economical answer to your problems from A-C.

All of this adds up to reliability, versatility and ease of operation. Make sure you talk over your next power transformer requirements with Allis-Chalmers.

A-4009

This Tap Changer Design Gives The Advantage of Point Contact

YOU CAN SEE from the diagram at left how the rounded point on a flat surface establishes a single current path per contact. This tap changer design meets five requirements for good design:

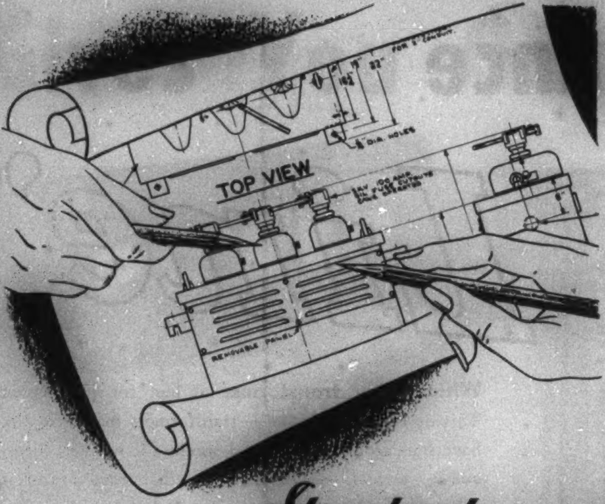


- **Contact members are flexible and self-aligning.**
- **Provides equal and positive contact pressure.**
- **Magnetic forces utilized to increase contact pressure.**
- **Gives a single established current path per contact.**
- **Strong wiping action cleans contact thoroughly when tap positions are changed.**

ALLIS-CHALMERS

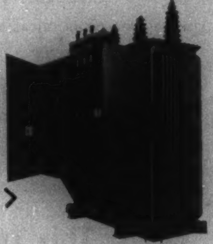
A-C ALLIS-CHALMERS

Milwaukee 1, Wisconsin



Standard WORKS WITH YOUR ENGINEERS WHEN YOU NEED *Special* TRANSFORMERS

25 KVA Dry Type Load Center Transformer with primary oil-filled fused cut-outs.



1000 KVA Special Unit Sub-Station — 66,000 to 2400 volts.

Working with you, STANDARD engineers can greatly assist in planning special transformer installations for a specfic need in your plant. Experienced STANDARD engineers have an excellent understanding of the particular needs of the electrical industry. Custom-designed and built transformers are their specialty. There's a STANDARD TRANSFORMER representative near you. Call him today!

THE *Standard*

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

A I E E

THREE STANDARDS

STANDARD FOR SWITCHGEAR ASSEMBLIES AND METAL-ENCLOSED BUS (1-52)

AIEE Standard No. 27 (which supersedes No. 27 issued in 1942) covers assemblies of switchgear devices such as switches, interrupting devices, control, metering, protective and regulating equipment with associated interconnections, enclosed bus, and supporting structures.

$0.60; 50 per cent discount to members of the AIEE

AMERICAN STANDARD GRAPHICAL SYMBOLS FOR SINGLE (ONE) LINE ELECTRICAL ENGINEERING DIAGRAMS (9-51)

Sponsored by the AIEE, the American Society of Mechanical Engineers and approved by the American Standards Association, Inc. This new standard, Y32.1.1-1951, contains graphical symbols for single (one) line electrical engineering diagrams. These diagrams indicate, by means of single lines and simplified symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein. It is intended that a single line diagram may be used to show essential components and functions in simplified form. Examples of diagrams and an index to graphical symbols are also included.

$1.40; 50 per cent discount to AIEE members

AMERICAN STANDARD FOR CAPACITOR UNITS (12-51)

AIEE Standard No. 18 and American Standards Association (ASA) No. C55.1 1951 supersedes the C55 issued in 1934. Sponsored by the AIEE and approved by the ASA, the standards in this section apply to shunt and series-connected capacitor units on a-c power transmission and distribution systems at nominal frequencies of 60 cycles or below, for the purpose of modifying the performance of the circuits at normal frequency.

$0.40; 50 per cent discount to AIEE members

The above new standards may be obtained from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York 18, N. Y.

4-53

EAGLE "CHEMI*SEALED" TURQUOISE DRAWING 4H

the Record proves that TURQUOISE holds a Needle Point

We sharpened a long, fine drafting point on an Eagle 4H TURQUOISE pencil, snapped it off and used it as the needle in an old-fashioned phonograph.

The point held without crumbling under the weight of the arm and the vibrations of the groove, and played the full record with surprising clarity!

Here is conclusive proof that the 100% "Electronic" graphite in the TURQUOISE lead gives it a particle fineness and compactness that produce non-crumbling, amazingly wear-resisting needle points.

100% "Electronic" graphite also gives unmatched denseness and durability, with the superior smoothness, uniformity and reproduction quality every draftsman dreams of.

PROVE IT YOURSELF: Write for a sample TURQUOISE pencil in any grade you desire, and test it at your own drafting board. Please name your regular supplier and this magazine.

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TURQUOISE
with 100% *"Electronic" Graphite

*®

EAGLE PENCIL COMPANY • NEW YORK • LONDON • TORONTO

UNIVERSAL MAKES PORCELAIN INSULATORS

IN ALL SHAPES AND SIZES

• The Universal Insulators shown are samples of the special types made to meet exact design specifications. Typical advantages include high dielectric and physical strength, resistance to temperature changes, vibration and shock . . . plus full protection against moisture, fumes, acids and corrosion.

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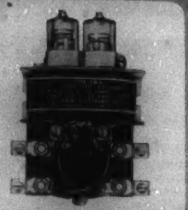

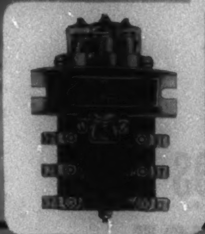

Mercury Plunger Relays FOR 2 and 3 POLE APPLICATIONS

- Hermetically Sealed
- Silent Operation
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- No Maintenance
- Mercury—Mercury Contact

The many advantages of mercury plunger construction are now available in relays for 2 and 3 pole applications.

Compact size and high current handling capacity (up to 60 amps) permits realistic savings in cost and space. For complete details just ask for our free catalogue—and don't forget—our engineering division is ready to serve on any of your relay problems.

EBERT ELECTRONICS CO.
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Now... for the first time KELLOGG magnetic impulse counter

It's simple! It saves space! It saves money! . . . Actuated by electrical impulses, the *Kellogg Magnetic Impulse Counter* performs the counting and marking function of a chain of 10 to 20 relays or of a two-magnet ten-point stepping switch, in less space and with top reliability! It has a wide application in many fields—from industrial control to any system where trains of impulses, such as generated by a telephone dial are to be counted.

- The long life normal to relay equipment!
- Occupies the space of only two telephone relays!
- Operates over the same wide range of pulse ratio and frequency as a chain of well-designed counting relays!

KELLOGG an IT&T ASSOCIATE

GET THE FACTS—MAIL COUPON TODAY!

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79 West Monroe St., Chicago 3, Ill. Dept. 63-D
Please send me complete information regarding the Kellogg Impulse Counter.

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Prompt notification of a change of address accomplishes three things simultaneously: change of address in the AIEE national records; change of mailing address for ELECTRICAL ENGINEERING; and notice to the local section to change the section mailing list. Therefore, if you have an address change, fill out the form below and mail it promptly to: AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Name ....

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City .... (Zone No.) .... State ....

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Membership No. .... (as shown in your mailing address)

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To assure a correct entry in the YEAR BOOK of the AIEE, please also furnish:

Company Name ....

Company Address ....

Department ....

Title (if one has been assigned) ....

Home Address ....

Are you a registered Professional Engineer? ....

4-53

INERT G-E SILICONE FLUID *(LEFT)* WON'T ATTACK POLYETHYLENE, WHEREAS MINERAL OIL *(RIGHT)* EATS THROUGH, SO . . .

To keep your farads up—*Specify* G-E SILICONE FLUID

Pulse-type capacitors for testing and aging hydrogen-thyratron and magnetron tubes are now made by Tobe Deutschmann Corporation using General Electric silicone fluid SF-96 as the liquid dielectric. Why? Because this inert fluid does not attack the polyethylene solid dielectric or undergo copper-induced oxidation as do mineral oils. Besides chemical inertness, SF-96 has excellent electrical and physical properties like these:

Electrical Properties:

Dielectric strength (0.1 in. gap)	35-40 kv
Power factor (1 megacycle)*	0.0001
Dielectric constant*	2.7
Volume resistivity (at 500 volts D.C.)	10^{15} ohms/cm^3

**Relatively constant over a wide range of frequencies and temperature*

Physical Properties:

Available in viscosities from 40-1000 centistokes

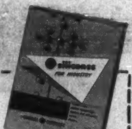
Appearance	water-white, clear
Pour point	as low as −85 F
Volatility	extremely low
Flash point	580-600 F
Stability	resists oxidation up to 300 F
Heat transfer	excellent

You've seen how G-E silicone fluids helped this capacitor manufacturer. Find out how they can help you by sending the coupon today!

G-E silicones fit in your future

GENERAL ELECTRIC

CLIP AND MAIL TODAY!



General Electric Company
Section 352-2B
Waterford, New York

☐ Please send me a free copy of *G-E Silicones for Industry.*

☐ Please send me product data on SF-96 silicone fluid.

I am interested in silicone rubber or resin for:

☐ Sleeving ☐ Wire and cable
☐ Rubber-coated glass cloth and tape
☐ Resin-coated glass cloth and tape
☐ Silicone-bonded mica products

Name________ Position________
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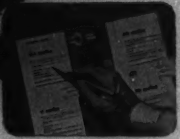
(In Canada, mail to Canadian General Electric Company, Ltd., Toronto)

IF YOU WORK WITH ELECTRICAL OR ELECTRONIC CIRCUITS...

CONTACT

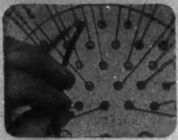
WAS MADE TO HELP YOU...

A color film with schematic animation and supporting narration . . . to help you select connectors engineered to your requirements and operating conditions. Disconnect system? Number of contacts? Voltage? Amperage? These and other factors are covered in this helpful film. In addition you'll learn how the printed Cannon Plug Guide (below) leads you to the *right* connector for any job. Request your free showing today.



CANNON PLUG GUIDE
. . . An easy-to-follow graphic aid.

CURRENT CAPACITY
and its relation to contact spacing.



SPACING AND NUMBER
of contacts involves many factors.

CANNON ELECTRIC

since 1915

Main office and plant, Cannon Electric Company, Los Angeles 31, California. Factories in Los Angeles, New Haven, Toronto. Representatives in principal cities.

"Contact", a 30-minute, 16mm Kodachrome sound picture, costs you nothing except 2-way transportation charges. You furnish sound projector. 24-page printed Plug Guide will be furnished for each person viewing film. To avoid delay request your booking for the film on coupon today.

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PHILADELPHIA 25, PENNSYLVANIA

Application Guide for

GROUNDING of INSTRUMENT TRANSFORMER SECONDARY CIRCUITS and CASES

The object of this guide, number 52, (based on the findings and conclusions of the AIEE Relay Committee) is to give recommendations as to whether all instrument and auxiliary transformers, irrespective of voltage, should be grounded, or just how this grounding should be done.

These recommendations apply to all instrument transformers, irrespective of the value of primary voltage or whether the primary windings of the transformers are connected to or in power circuits, or whether these primary windings are connected in the secondary circuits of other instrument transformers.

There is no charge for copies.

Order Department

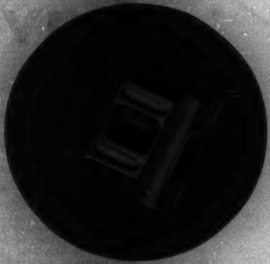
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York
18, N. Y.

4-53

THERE IS NO SUBSTITUTE FOR MORE THAN

25 Years Experience

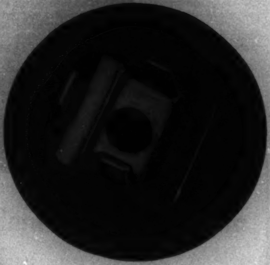
When Making Copper to Aluminum Connections Use Cast Aluminum Connectors with Copper Liners



For Continuity of Service be sure, by test, copper liners are properly bonded to aluminum clamping members.

Copper Liners Securely bonded to aluminum clamping members by an exclusive process which prevents voids in bond. Years of satisfactory connections certify the use of these connectors.

Be Sure—Buy Aluminum Connectors, Clamps, fittings and accessories backed with more than 25 years of electrical, mechanical and metallurgical knowledge and manufacturing experience gained in meeting and maintaining the most exacting standards of the electrical industry.



Cast Aluminum Connector of other manufacture

•

TEST

Copper Liners Easily Peeled Loose from Aluminum Clamping Members

Examination Discloses:

Poor bond with voids allowing moisture and atmospheric contamination to enter between aluminum clamping member and copper liner causing electrolytic action and connector failure.

OUR PRODUCTS ARE QUALITY CONTROLLED FROM INGOT TO FINISHED PRODUCT

Consult one of our nearest eighteen representatives or contact our main office

POWER CONNECTORS
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CLAMPS
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FITTINGS
and
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ANDERSON BRASS WORKS
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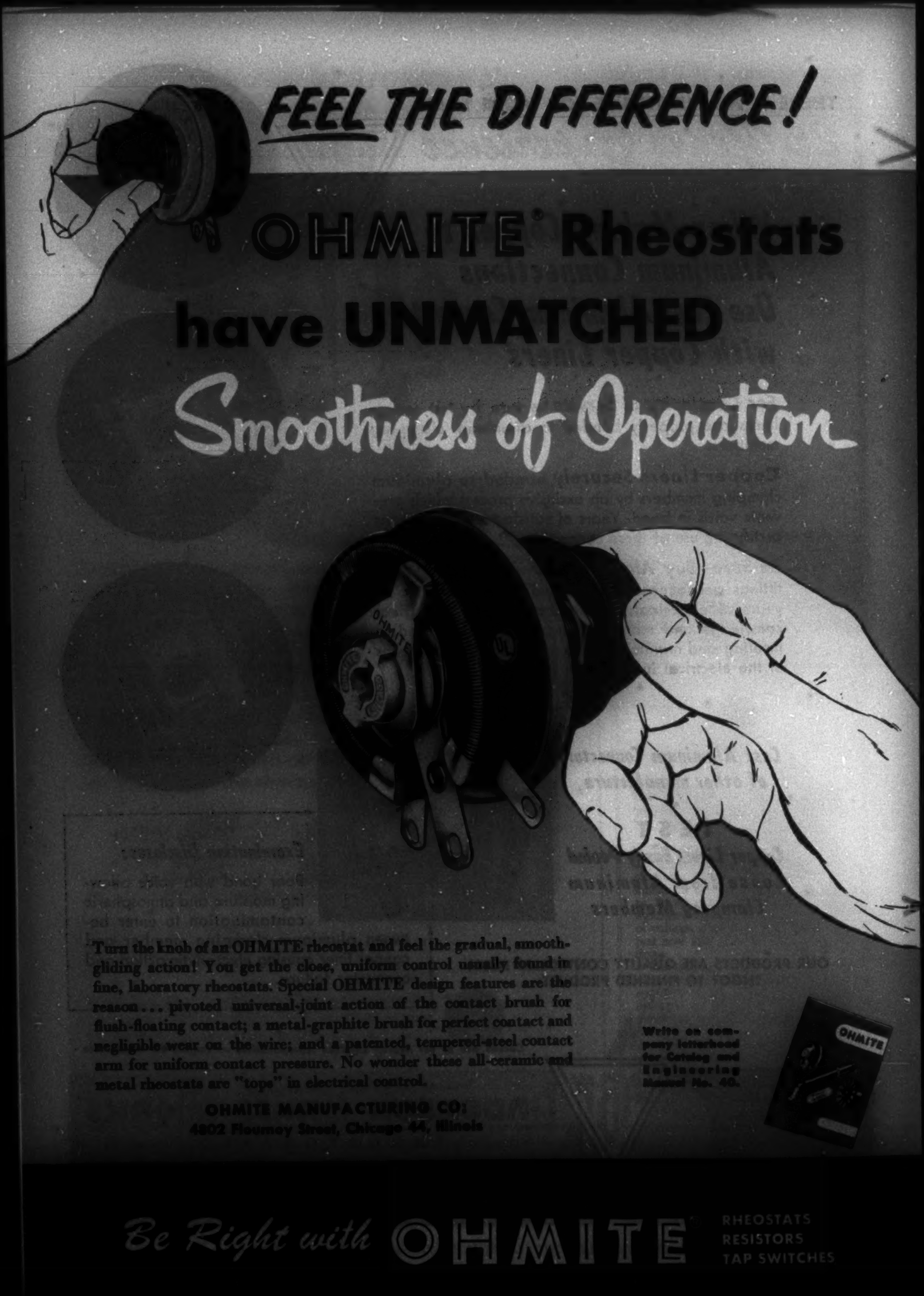

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OHMITE® Rheostats have UNMATCHED Smoothness of Operation

Turn the knob of an OHMITE rheostat and feel the gradual, smooth-gliding action! You get the close, uniform control usually found in fine, laboratory rheostats. Special OHMITE design features are the reason . . . pivoted universal-joint action of the contact brush for flush-floating contact; a metal-graphite brush for perfect contact and negligible wear on the wire; and a patented, tempered-steel contact arm for uniform contact pressure. No wonder these all-ceramic and metal rheostats are "tops" in electrical control.

OHMITE MANUFACTURING CO.
4802 Flournoy Street, Chicago 44, Illinois

Write on company letterhead for Catalog and Engineering Manual No. 40.

Be Right with OHMITE®

RHEOSTATS
RESISTORS
TAP SWITCHES

BIBLIOGRAPHY
ON
POWER
CAPACITORS
1925-1950

This Bibliography (S-43) was prepared as an activity of the Capacitor Subcommittee of the AIEE Committee on Transmission and Distribution and is intended to present a consolidated reference to the principal significant literature in the field of capacitor applications to power circuits. Only basic and original material has been presented.

Contents of this new publication include:

(1) LIST OF PERIODICALS

(2) BIBLIOGRAPHY ON POWER CAPACITORS, catalogued into the following divisions:

Capacitor Economics

Capacitors (*their design, construction, operation, and maintenance*)

Capacitor Applications (*miscellaneous, and general, industrial, and utility power factor correction*)

(3) BOOKS AND RELATED BIBLIOGRAPHIES

(4) AUTHOR INDEX

The price is $1.25 (no discounts possible). Copies may be obtained from:

Order Department
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

4-53

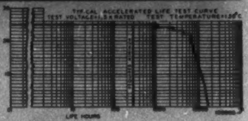
Further Proof of

Getting to the bottom of things

. . . is most clearly demonstrated by what we are doing every hour of every day — year in and year out — to make a finer fixed CAPACITOR.

One of the many things you as users are interested in is the "LIFE OF THE CAPACITOR" under a multitude of operating conditions. We in the FAST organization have spared no expense to give you honest-to-goodness answers on this important factor in providing quality capacitors.

What follows is a summary of what we are doing to give you just that . . .



I: RESEARCH and DEVELOPMENT TESTS

AC and DC tests at various temperatures and voltages.

1—Investigation of Impregnants: (a) New impregnants AC—synthetic and natural oils. DC—oils, resins and waxes. (b) Studies of impurities and additives.

2—Investigation of electrode separators and electrode materials: (a) Modified kraft papers—low PF varieties and sundry densities. (b) Films—regenerated cellulose, polystyrene, teflon, "Mylar"*, Etc.

3—Number of groups tested: AC; over 800 involving more than 8000 units. DC; over 3300 involving more than 70,000 units.

4—Duration of tests: AC; many have been continuously under test for over 6 years. DC; many have been continuously under test for over 10 years.

5—Voltage range of tests: AC; 70 to 2400 volts at 60 and 400 cycles. DC; 140 to 44,000 volts.

6—Temperature range of tests: AC; Room to 130°C. DC; —55°C to +150°C.

II: PRODUCTION TESTS

A. Alternating Current

1—Heat runs on production lots—ultimate surface temperature rise.

2—Ultimate life hours of current production (periodic tests run).

B. Direct Current

1—Civilian Production: (a) ultimate life hours of capacitors taken from current production. (These test runs comprise over 1600 groups involving more than 16,000 units)

(b) Ultimate life hours of capacitors after being stored in cartons from 1 to 24 months under normal variations in humidity and temperature. (These test runs comprise over 230 groups involving more than 2300 units)

2—Military Production: (a) Test to applicable specifications (Jan. C-25; Jan. C-91; U. S. Army 71-1667; Etc.)

(b) These test runs comprise over 3300 groups involving more than 19,000 capacitors.

Please note Carefully: at least 80% of the 115,300 capacitors included in the above tests were tested to destruction at voltages from 1½ to 4 times rated and at maximum rated—or in excess of—operating temperatures. Many outside this group have not failed to date. Importantly too, this is a continuous policy of the company in sustaining our testing program throughout every day—year after year.

So with pardonable pride may we suggest QUALITY CAPACITORS is more than a "catch-phrase" as applied to the FAST organization . . . and another link in the chain of GETTING TO THE BOTTOM OF THINGS?

* *Du Pont trade-mark for Polyester Film*

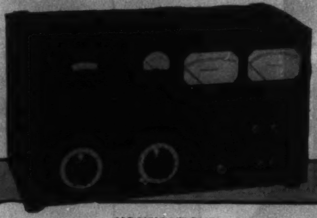
JOHN E. FAST & CO.

Capacitor Specialists For Over A Third of A Century

3169 North Pulaski Road, Chicago 41, Ill.

"WHEN YOU THINK OF CAPACITORS . . . THINK FAST"

NEW! UHF TELEVISION
Standard Signal Generator



MODEL 84-TV
300—1000Mc.

SPECIFICATIONS
FREQUENCY RANGE: 300-1000 megacycles.
OUTPUT: .1 Microvolt to 1 Volt, across 50 Ohms.
OUTPUT IMPEDANCE: 50 Ohms coaxial.
MODULATION: Internal 400 cycle, continuously variable from 0 to 30%. Provision for external modulation of 50 to 20,000 cycles.
LEAKAGE: Negligible.
SIZE: Overall Dimensions: 11¾ inches high, 19 inches wide, 11 inches deep.
WEIGHT: Approximately 40 pounds.
POWER: 115 volts, 60 cycles, 120 watts.
Write for complete details

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
TV Standard Signal Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Megacycle Meters
Intermodulation Meters
TV & FM Test Equipment

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

Here are four typical transformer designs of Oil Burner Ignition Transformers, Television Transformers, Plastic Sealed Transformers and Hermetic Sealed Transformers.

Acme ACME Electric

Whether your need for transformers involve a household product, commercial installation or use by the military services, your best source of supply is Acme Electric.

Acme Electric is a thorely trained organization, with experience to build special transformers in production quantities to high quality standards.

We have complete facilities to produce and test transformers covered by MIL-T-27 specifications.

TRANSFORMERS

ACME ELECTRIC CORPORATION
224 WATER STREET • CUBA, N. Y.

Acme ACME Electric
TRANSFORMERS

SPECIFY
COPACO

COPACO
electrical insulating papers

You be the judge! What you want in electrical papers, you'll find in Capaco-51 or Copaco-51S Both meet all Class A requirements. And in both, only the finest raw materials are used . . . resulting in a very low percentage of extractables. The 51S grade, normally furnished in thicknesses over .010, has a synthetic resin bond giving maximum adhesion.

COPACO 51
COPACO 51S

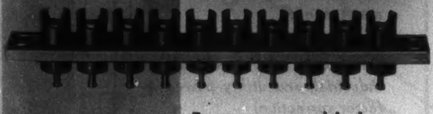
Write for descriptive folder, with actual samples of Cottrell Paper and list of Cottrell representatives. Address: Cottrell Paper Co., 88 Purchase St.—EE3—Fall River 3, Mass.

Representatives everywhere

Copaco ELECTRICAL INSULATING PAPER

Curtis Terminal Blocks Make Better Connections Economically—Quickly. A type for every purpose.

CURTIS
Type "FTS" Terminal Blocks
simplify internal to external feed-thru connections.



Factory assembled in 1 to 16 terminals

Sturdily constructed and designed for circuits carrying up to 300 volts, 20 amperes, the Curtis "FTS" Feed-Thru Terminal Blocks ideally satisfy the demand for sub-panel and chassis construction with combination screw and solder terminals. The individual bakelite feed-thru terminals are permanently secured in a metal strip. Simplify your feed-thru connections with the "FTS."

Write for Bulletin DS-115. Also, ask about the wide selection of other Curtis Blocks available.

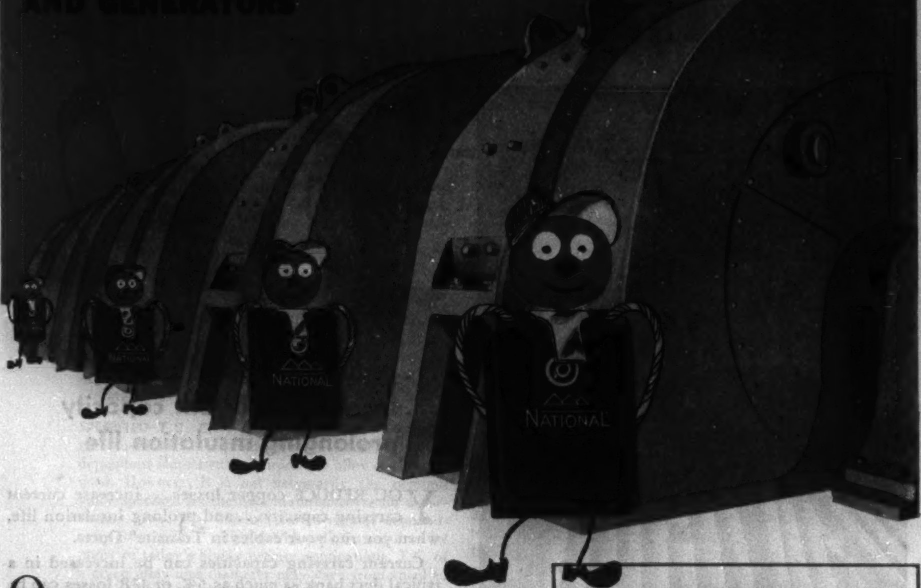
CURTIS DEVELOPMENT & MFG. CO.
3216 North 33rd Street, Milwaukee 16, Wisconsin

Where Quality Counts Most . . . Count on

NATIONAL CARBON BRUSHES

TRADE-MARK

FOR MAIN-DRIVE MOTORS AND GENERATORS



Quality *counts* most where failure *costs* most . . . in the main drives and generators upon whose sustained efficiency uninterrupted production depends.

Chances are you're already *paying* for the best brushes in these and other vital applications; make sure you *get* the best by specifying "National" brushes.

For toe-to-toe and tandem-type holders, there are "National" STANDARDIZED brushes to meet your requirements . . . delivering not only the uniform high quality and dependability of *all* "National" brushes, but the added conveniences of uniform packaging, delivery from stock and the big economy of a *flat unit price!*

HERE'S WHY "NATIONAL" BRUSHES ARE BETTER:

- Service proved dependability
- Closely controlled commutation factor
- Minimum commutator wear
- Long life
- Uniformity from shipment to shipment

NATIONAL STANDARDIZED BRUSHES

BETTER—PRODUCT—PACKAGE—PRICE—FASTER

The term "National", the Three Pyramids device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

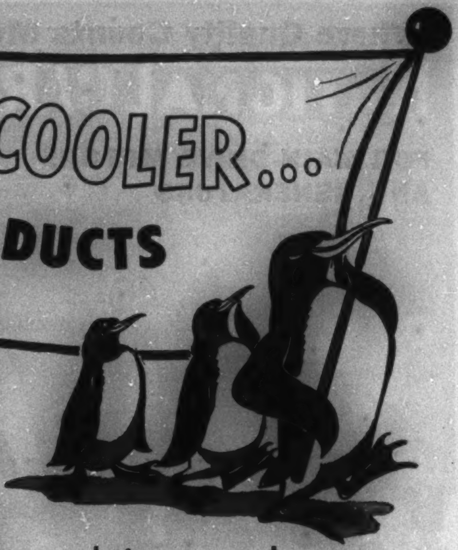
NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.
District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
In Canada:
NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg

Cables run COOLER...
in TRANSITE DUCTS

How Transite Ducts increase current carrying capacities

Type cable 3 cdr. 500 MCM Compack Sector, 15 KV
(6th Edition AEIC Spec.)
No. of cables—3 (all loaded in one bank)
Daily Load Factor—75%
Earth Temp. ambient—20 C

	Transite	Other
Total Therm. Res. to Dielectric Loss (C watts/ft.)	5.66	6.17
Total Therm. Res. to Copper Loss (C watts/ft.)	4.44	4.95
Temp. Rise from Dielectric loss (C)	1.9	2.1
Allowable Rise for Copper loss (C)	59.1	58.9
Allowable Watts per ft. cable	4.44	3.96
Allowable Current—(Amps. per cdr.)	386.	365.
Allowable Current—(Relative %)	105.6	100.



... reducing copper losses
... increasing current capacity
... prolonging insulation life

YOU REDUCE copper losses ... increase current carrying capacity ... and prolong insulation life, when you run your cables in Transite* Ducts.

Current carrying capacities can be increased in a typical duct bank as much as 5%, or I²R losses can be reduced 11%, for cables located in Transite as compared with other ducts used for power circuits.

And, Transite Ducts assure permanent duct banks because Transite is incombustible; is immune to rust and rot; is unaffected by electrolysis; will not slag under action of an arc, and will retain its high original strength.

An unusually smooth bore assures no injury to cable sheath, either in natural movement under load, or when pulling-in cables. Long, lightweight lengths can be quickly and economically installed. In addition, a full line of fittings simplifies even the most complicated of installations.

For full information on Transite Ducts, write for Data Book DS-410. Johns-Manville, Box 60, New York 16, N. Y.

*Reg. U. S. Pat. Off.

Johns-Manville *Transite Ducts*

TRANSITE KORDUCT—
for installation in
concrete

TRANSITE CONDUIT—
for exposed work and
installation underground without
a concrete encasement

WHAT ABOUT

Temperature Coefficient

IN *PRECISION WIREWOUND* RESISTORS?

Specify a precision resistor for electronic equipment you are designing, and you frequently become involved in temperature coefficient. At this point, many engineers do not fully understand the temperature coefficient they select from a table.

First of all, the temperature coefficient (T.C.) of a resistor is the variation in resistance (ohmic value) as the temperature changes. It is expressed as a change per degree Centigrade—either Per Cent, Parts/Million, or Ohms/Ohm. It should not be confused with stability—the lack of resistance change at a given temperature after aging, temperature cycling, or overload testing.

SPECIFIED T.C. CAN BE INACCURATE: Temperature coefficient of a precision wire-wound resistor is dependent almost entirely upon the alloy of the wire used. However, it is *not* necessarily the *nominal* value specified by the wire manufacturers for a particular alloy. Wire manufacturers cannot economically control T.C. within the close limits required by many of today's highly precise applications. T.C. of a given alloy and diameter may vary from spool to spool, and even within the same spool.

The variation in T.C. is particularly great in the "E" alloys—commonly called "special low-T.C. wire." For example, Shallcross' laboratory tests have shown T.C. to vary from higher than ±.004%/°C. to lower than ±.001%/°C. for resistors wound with "E" alloys *nominally* ±.002%/°C.

THE ONLY WAY TO T.C. ACCURACY: Shallcross manufactures resistors wound with all commonly used alloys made in the following degrees of T.C. quality:

1. *Resistors wound with a designated alloy and offering no guarantee of T.C. other than the limits established by the wire manufacturer.*
2. *Resistors wound with wire from spools pre-tested and selected for T.C.* Determination and recording of the T.C. of each spool of "E" alloy wire is part of the standard Shallcross inspection procedure. Selection assures only that the yield of resistors within specific T.C. limits will be high. It does *not* assure that *all* resistors wound with tested wire will be within the T.C. limits of selection.
3. *Resistors with a* **guaranteed** *T.C. over a given temperature range.* Pre-selected wire is used to wind these resistors, readings are taken at several temperatures, and the T.C. is computed. Only individual resistors within the customer's specified T.C. limits are released. Although time-consuming, this is the *only* known way to guarantee a particular temperature coefficient or, in the case of "E" wire, the much publicized *range* of ±.002%/°C.

Further details on T.C. and other resistor characteristics are available in Shallcross Bulletin R-3C.

SHALLCROSS MANUFACTURING COMPANY • 11 LINCOLN AVENUE, COLLINGDALE, PA.

The first of a series to promote a better understanding of the performance characteristics of precision wire-wound resistors.

Shallcross

Custom Built Dry-Type Transformers *and* D.C. Saturable Reactors

Engineered by SORGEL to meet your requirements

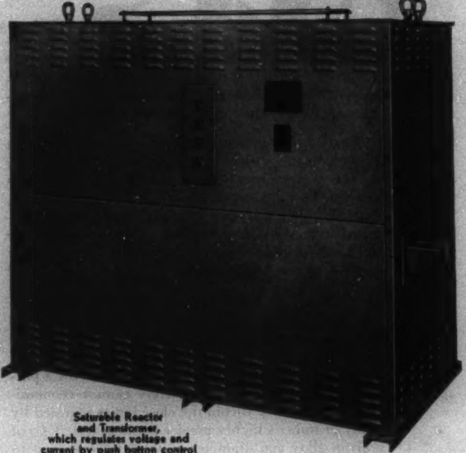
Our experienced engineering staff, expert craftsmanship, and complete manufacturing facilities, enable us to develop that degree of perfection in our product which is so much appreciated by discriminating engineers and contractors.

D.C. Saturable Reactors

10 to 500 Kv-a. single phase.
30 to 1500 Kv-a. poly-phase.
All voltages up to 5000 volts.

Dry-Type Transformers

¼ to 1500 Kv-a. single phase.
1 to 3000 Kv-a. poly-phase.
All voltages up to 15,000 volts.



Saturable Reactor and Transformer, which regulates voltage and current by push button control

1000 Kv-a. 4160 volt Special Testing Transformer, with low voltage multiple secondaries.

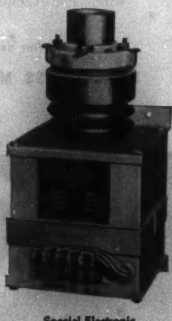
If you will let us know what your requirements are we will submit our recommendations and helpful information.

Also a complete line of

Standard Air-Cooled Dry-Type Transformers

Unit Substations

Complete with switchgear



Special Electronic Transformer

Sales Engineers in Principal Cities

SORGEL ELECTRIC CO., 846 West National Ave., Milwaukee 4, Wis.

Pioneers in the development and manufacturing of Air-Cooled Dry-Type Transformers—Over 35 Years

THERE'S A KAISER ALUMINUM EC DISTRIBUTOR CONVENIENTLY LOCATED TO SERVE YOU

City Electric Distributors, Inc.
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Interstate Electric Co. of Shreveport, Inc.
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The Korsmeyer Company
Virginian Electric, Inc.
Westinghouse Electric Supply Co.

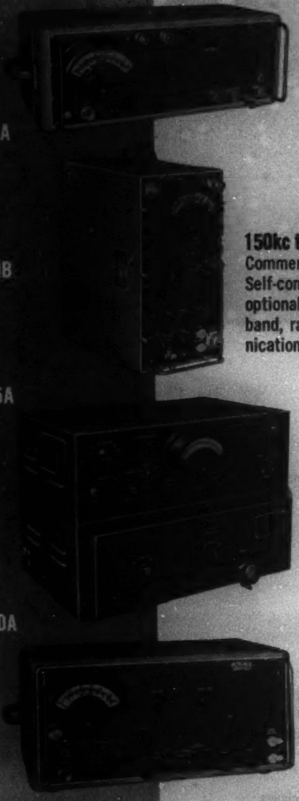
Take advantage of the many services offered by your nearby Kaiser Aluminum ECDistributor. Here are a few:

- He has available large stocks of Kaiser Aluminum Conductor.
- He insures fast delivery to help reduce your inventory.
- His specialized knowledge helps solve your individual problems.
- He provides top-notch engineering services.
- He keeps you abreast of latest developments and techniques.
- He gives you friendly, personal attention on any size order.

NEOPRENE AND POLYETHYLENE COVERED CONDUCTOR, SOLID AND STRANDED • SELF-SUPPORTING TRIPLEX CABLE • ACSR ALL ALUMINUM CONDUCTOR

Kaiser Aluminum

setting the pace—in growth, quality and service



STANDARD
Radio Interference and Field Intensity
MEASURING EQUIPMENT
Complete Frequency Coverage—14kc to 1000 mc!

VLF
14kc to 250kc
Commercial Equivalent of AN/URM-6B.
Very low frequencies.

HF
150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has B.F.O.

VHF
15mc to 400mc
Commercial Equivalent of TS-587/U.
Frequency range includes FM and TV Bands.

UHF
375mc to 1000mc
Commercial Equivalent of AN/URM-17.
Frequency range includes Citizens Band and UHF color TV Band.

These instruments comply with test equipment requirements of such radio interference specifications as MIL-I-6181, MIL-I-16910, PRO-MIL-STD-225, ASA C63.2, 16E4, AN-I-24a, AN-I-42, AN-I-27a, MIL-I-6722 and others.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Boulevard, Hollywood 38, California

(Continued from page 34A)

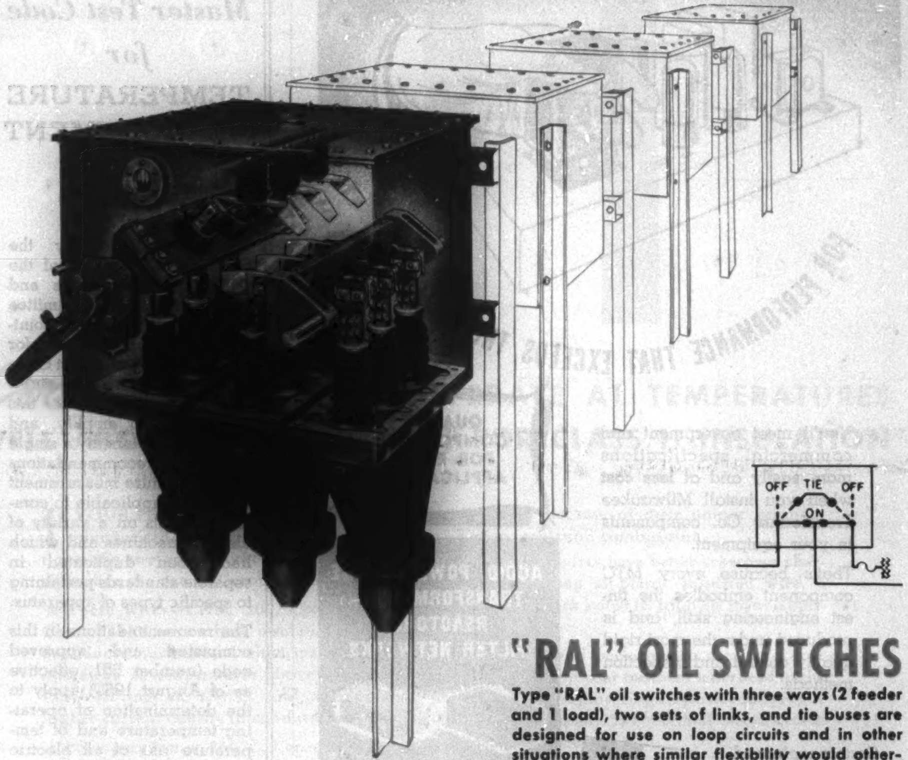
fier channels have a high input impedance of 2.5 megohms on the 0.01- to 0.1-volt-per-millimeter range and greater than 10 megohms on all other ranges. Limiting circuits in the amplifier protect galvanometer movements and keep pens in their pivots when an overload is applied. The balance poteniometer may be used to adjust the pen on the recorder chart electrically and to balance out any input d-c signal for greater amplification of the a-c component. Power requirements are 105 to 125 volts, 60 cycles, single phase, and about 150 watts.

Circuit Breaker. Square D has announced a new circuit breaker, the *XO*, for lighting and general-purpose loads. Operating features include quick-made, quick-break operating mechanism to eliminate teasing of contacts; positive operation assured by direct action of the handle on the blade with no intermediate links or couplings; automatic relatching which eliminates complicated restoration of service; ambient compensation to prevent nuisance tripping due to increased temperatures; plug-in mounting for speedy installation and flexibility; shock resistance which reduces needless tripping due to vibration; and thermal-magnetic protection for both moderate and extremely heavy overloads. A new approach has been used to prevent dangerous tampering. That is, 15- and 20-ampere single-pole circuit breakers are 1/2 inch wide while large capacity 30-, 40-, and 50-ampere ratings are 3/4 inch wide per pole and are only available in double-pole construction. Thus, it is impossible to interchange larger capacity circuit breakers with smaller rated units. The complete *XO* load center line, covering a range of from 1 to 32 circuits, is made up of only six basic boxes. Single-phase 3-wire, 3-phase 4-wire, main lugs and main circuit breakers, and general-purpose or raintight enclosures are available. Write Square D Company, 6060 Rivard Street, Detroit 11, Mich., for details.

Frequency and Modulation Meter. A frequency and modulation meter for use in the maintenance of 2-way radio systems has been announced by the General Electric Company's Electronics Division, Syracuse, N. Y. The meter, type *ST-13-A*, measures modulation swing and carrier frequency of frequency-modulation transmitters, and features both high and low radio-frequency output for receiver alignment. It is available with either one or two crystals, for servicing single- or 2-frequency systems, in both the low and medium and high bands. The meter is available with or without a crystal oven, and with crystal tolerances ranging from 0.0005 to 0.0025 per cent. The oven, available in two ratings, 38 and 75 degrees centigrade, is powered from any external 6-volt power supply. The meter is available in several models, each having different limits of operation. For further information write Department N-14, In-

(Continued on page 58A)

PROVIDE SAFE SECTIONALIZATION FOR CABLE SYSTEM FLEXIBILITY WITH G & W LOAD BREAK OIL SWITCHES



"RAL" OIL SWITCHES

Type "RAL" oil switches with three ways (2 feeder and 1 load), two sets of links, and tie buses are designed for use on loop circuits and in other situations where similar flexibility would otherwise require three separate oil switches with correspondingly greater expense for equipment, installation, and space.

These oil switches materially reduce the length of time required for restoring service in case of trouble, or for isolating a circuit to make changes. Load break disconnection of a circuit is accomplished by manually operating an external lever —without opening the tank or breaking the oil and moisture seals.

Bulletin DB51 gives complete data and prices. Write for your copy or ask your representative.

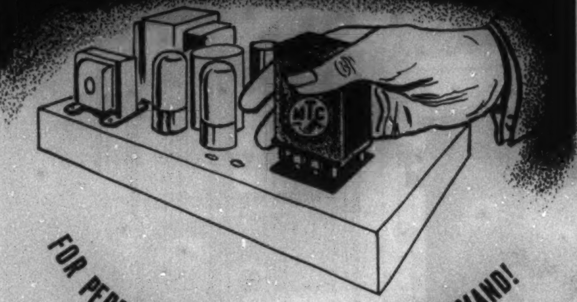
G & W **ELECTRIC SPECIALTY CO.**

7780 Dante Avenue, Chicago 19, Illinois

Cable Terminating, Connecting and Sectionalizing Devices
Representatives in principal cities of U. S. A.
In Canada—Powerlite Devices, Ltd., Toronto and Montreal

G & W "FORETHOUGHT" DB-20 SHOWS HOW "RAL" SWITCHES ARE COMBINED WITH POWER FUSES. SEND FOR YOUR COPY, THERE IS NO OBLIGATION.

Put *Milwaukee* Transformers into your equipment . . .



FOR PERFORMANCE THAT EXCEEDS THE DEMAND!

QUALITY COMPONENTS FOR EVERY APPLICATION

You'll meet government and commercial specifications **more easily** and at **less cost** when you install Milwaukee Transformer Co. components in your equipment.

That's because every MTC component embodies the finest engineering skill, and is produced under the most rigid quality control and inspection methods.

AUDIO, POWER, PULSE TRANSFORMERS — REACTORS, FILTER NETWORKS

Custom-engineered components for MIL-T-27 government, and commercial requirements. Quotations submitted upon request.

Write for your *Free* copy of Brochure MTR-1

SPECIALTY ENGINEERING . . . DESIGN, DEVELOPMENT AND PRODUCTION

MILWAUKEE TRANSFORMER CO.
5233 NORTH HOPKINS STREET
MILWAUKEE 9, WISCONSIN

MTC — MILWAUKEE TRANSFORMER COMPANY — MILWAUKEE, WISCONSIN

A I E E

Master Test Code for
TEMPERATURE MEASUREMENT
of Electric Apparatus

Upon suggestion by the Standards Committee of the AIEE, the Instruments and Measurements Committee voted in 1941 the appointment of a subcommittee for preparing a Master Test Code for Temperature Measurement. The objective of this action was to amplify, and ultimately replace by a single code, those recommendations on temperature measurement which are applicable to commercial tests on a variety of electric machines and which had been duplicated in separate standards pertaining to specific types of apparatus.

The recommendations in this completed and approved code (number 551, effective as of August 1950) apply to the determination of operating temperature and of temperature rise of all electric machines, instruments, and apparatus in common use, where temperatures do not exceed 500 degrees centigrade. Standards pertaining to permissible temperature rise and corrections are not included.

Price: $0.80 to non-members, $0.40 to members of the AIEE. Orders should be sent to:

Order Department
AMERICAN INSTITUTE OF
ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

4-53

CLASS H+

Ceroc® MAGNET WIRES OPERATE AT TEMPERATURES WELL ABOVE THE 180°C. LIMIT FOR CLASS H INSULATION

IF YOUR PROBLEM is the design of reliable miniaturized electrical equipment, investigate the size and weight savings made possible thru the use of Ceroc Magnet Wires.

★These wires—Ceroc 200, Ceroc ST, and Ceroc T—all have a base insulation of a thin flexible ceramic material which makes possible operation at temperatures above the present Class H limit of 180°C. And thus permits higher current density in conductors.

★For operation at 250°C, Ceroc ST (single Teflon) and Ceroc T (double Teflon) have a tetrafluoroethylene overlay while Ceroc 200 for 200°C. application has a silicone coating on the ceramic to facilitate winding.

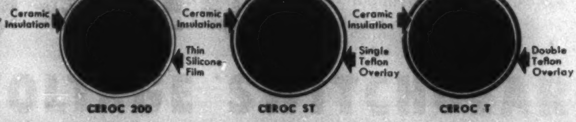
★Ceroc ST and Ceroc T have been used successfully to 350°C. in short-time military applications because of their unique ceramic-Teflon insulation combination.

★ All three wires have better crossover characteristics than all-plastic insulated wire, a very important consideration in many applications.

★ For size and performance data on Ceroc wires, write on your business letterhead to the Application Engineering Department, Sprague Electric Company, 321 Marshall Street, North Adams, Massachusetts.

★ And remember, with its years of experience in quality control, the Sprague Electric Company delivers to you a product of uniformly high quality to meet and exceed conservative engineering performance design guides.

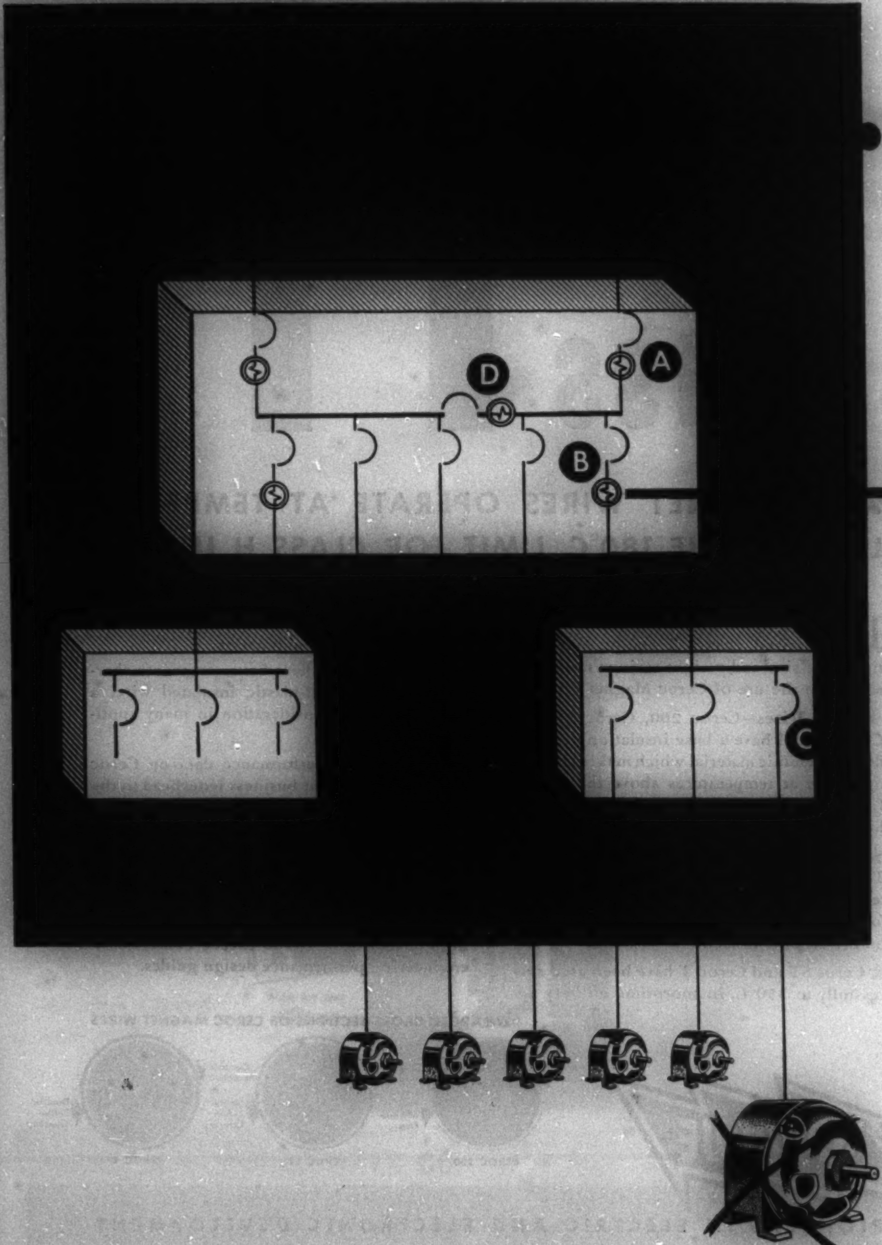
ENLARGED CROSS-SECTIONS OF CEROC MAGNET WIRES



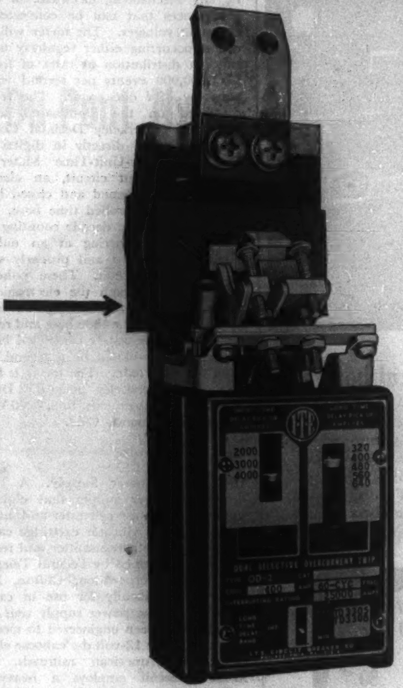
SPRAGUE®

PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

EXPORT: Cable SPREXDIV, NORTH ADAMS, MASSACHUSETTS


A
D
B
C

or shutdown?



Selective tripping on I-T-E Circuit Breakers isolates system faults, boosts system reliability

What selective tripping is

Selective tripping is the economical means for providing reliable electrical service with complete freedom from general interruption. With selective tripping, several circuit breakers may be used in series; yet on overcurrent or fault, *only* the faulted circuit is interrupted.

What it does

Consider the following cases for a typical low-voltage system:

Without selective tripping—the overloaded motor in the diagram at left could cause breakers C, B, D, and A to trip, shutting down a boiler, a plant, or an entire system. This *will* happen, if the system does not include circuit breakers equipped for selective tripping.

With selective tripping—only breaker C will trip. A motor saved, one circuit interrupted, while *the rest of the system continues to operate—unaffected.*

I-T-E trip device is a compact circuit breaker component

Selective tripping in low-voltage systems is easily applied with I-T-E Circuit Breakers. The breakers are simply equipped with compact I-T-E *direct-acting dual-selective overcurrent trip devices.* No expensive current transformers, no relays, no added switchboard panels are required. The trip devices are fitted as an integral part of the breaker.

Consider I-T-E selective tripping for your system

In central stations, in manufacturing plants, in the processing industries—I-T-E selective tripping has saved in initial investment, boosted system reliability, and reduced breaker maintenance. If you're planning a new low-voltage switchboard application, investigate the advantages of direct-acting I-T-E trip devices.

LOW-VOLTAGE SWITCHGEAR

I-T-E CIRCUIT BREAKER CO. • 19TH AND HAMILTON STS. • PHILADELPHIA 30, PA.
CANADIAN MFG. & SALES: EASTERN POWER DEVICES, LTD., TORONTO

Easy-reading K-24 instruments

Give you switchboards that weren't practical before

One man at one of these new switchboards can handle a complete control room or industrial process. It's a marvel of efficiency.

Compactness is what makes these boards efficient. If they were too long and strung out, they would defeat their purpose.

One important factor in keeping these boards compact is the *exceptionally good readability* of the Westinghouse Full-View K-24 instruments. See how this works:

These instruments are readable from wide angles. They can be mounted high on the board—and are fully legible from underneath. Old-style instruments would be mounted lower and strung out horizontally, making for long unwieldy boards.

Another factor: the operator can read Full-View K-24 instruments from much farther away. From one place "he covers more ground". Result: a more compact, easy-to-handle layout.

When you need *any* kind of electrical measuring instruments—call in Westinghouse. And write now for Booklet B-4695, "Getting A Full Measure". Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. J-40428

40
60
20
80
100
D-C
AMPERES

No shadows, no glare, no parallax interfere when you use the Full-View K-24 instruments. The climax of 65 years of intensive study, they are a triumph of optical engineering.

YOU CAN BE SURE...IF IT'S
Westinghouse

EVERYTHING YOU NEED IN METERS AND INSTRUMENTS

(*Continued from page 52A*)

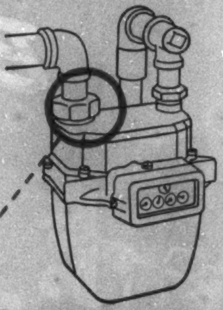
quiry Section, General Electric Company, Electronics Park, Syracuse, N. Y.

Events-Per-Unit-Time Meter. The Berkeley Events-Per-Unit-Time Meter model *5558* is a high-speed electronic counter combined with an accurate time base to provide an instrument that automatically will count and display the number of events that occur during a precise time interval. These events may be any mechanical, electrical, or optical occurrences that can be converted into changing voltages. The meter will count events occurring either regularly or with random distribution at rates of from 20 to 1,000,000 events per second with an accuracy of *1* one count. The result is displayed on the illuminated number panels of 6 Berkeley Decimal Counting Units and read directly in digital form. The Events-Per-Unit-Time Meter consists of an input circuit, an electronic gate which is opened and closed by the oven crystal controlled time base, and a series of electronic decade counting units. The Events, occurring at an unknown rate, are amplified and properly shaped by the input circuit. These pulses are then passed through the electronic gate to the counting units. The gate is opened by a signal from the time base and remains open for an accurately controlled interval of time and is closed by a second signal from the time base. The meter is manufactured by Berkeley Scientific Division of Beckman Instruments, Inc., 2200 Wright Avenue, Richmond, Calif.

D-C Train Power Supply. A 12-volt d-c train power supply that eliminates the need for an a-c converter and incorporates a plug-in vibrator cartridge capable of operating both transmitter and receiver has been developed by Federal Telephone and Radio Corporation, Clifton, N. J. Designed specifically for use in caboose installations, the power supply unit (type *M322-1*) has been engineered to meet the adoption of the 12-volt d-c caboose electric system by American railroads. The *M322-1* circuit employs a heavy-duty railroad-type plug-in vibrator with full-wave tube rectifiers, weighs 35 pounds, and has a temperature range of −30 to 60 degrees centigrade. Nominal input voltage is 12.6 volts direct current, while the output voltage is rated at 300 volts direct current at 110 milliamperes for the receiver and 300 volts direct current at 325 milliamperes for the transmitter.

Push-Button Oscillator. The Krohn-Hite Instrument Company, 580 Massachusetts Avenue, Cambridge, Mass., has announced a new Model *440-A* push-button oscillator designed for applications requiring very low distortion or extremely good frequency stability and resetability. It provides both sine waves and square waves at any frequency between 0.01 cycles and 100 kc. For fine control of

(*Continued on page 64A*)



Du Pont Nylon plastic protects against corrosion

LINER OF
DU PONT NYLON

Liner molded for
Universal Controls Corp.,
Dallas, Texas

Insulating liner lengthens life of gas and water pipe systems

A big problem affecting the life of underground gas or water pipes is electrolytic corrosion. It may be caused by contact between dissimilar metals or by stray electrical currents. Such corrosion can cut pipe life in half.

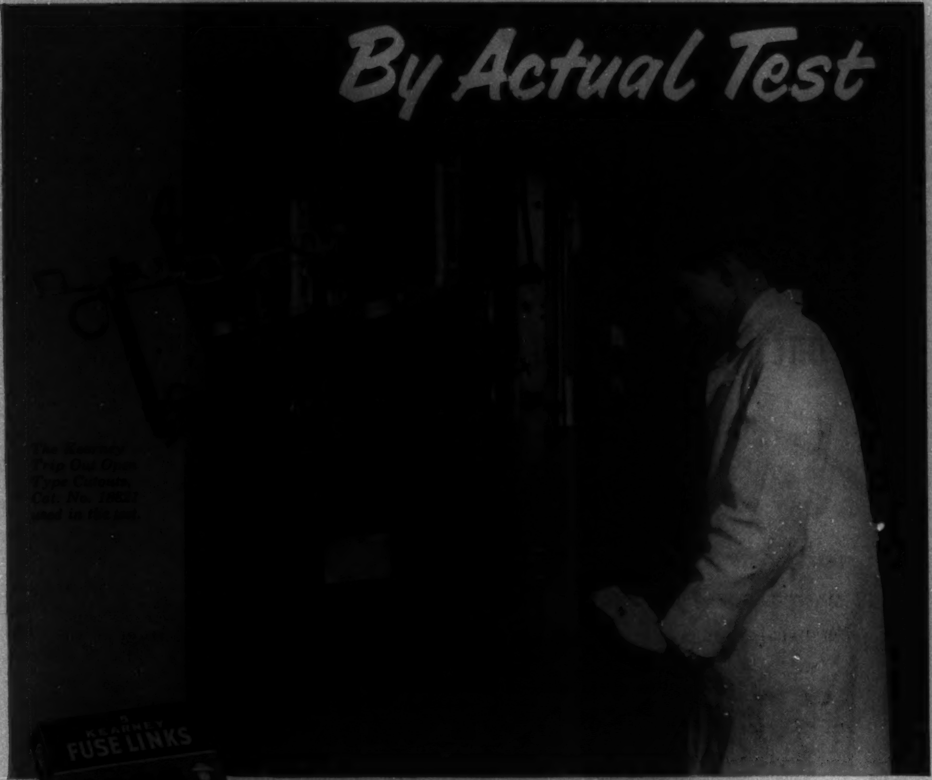
To solve the problem, Universal Controls Corporation designed a special nut to join the pipeline with the gas or water meter. It consists of an outer steel shell fitted with a threaded liner of Du Pont nylon plastic. The nut breaks the conductive circuit formed by the pipe and prevents the flow of current. Its success depends on a liner material that is non-conductive and provides a year-round, leak-proof mechanical joint.

Du Pont nylon has the electrical properties to furnish the needed insulation. Its resiliency and strength give a good mechanical joint winter and summer. And nylon's toughness and abrasion resistance provide long, trouble-free service. In use, the nut increases pipe life . . . often doubles it.

This is another of the over 800 examples where Du Pont nylon is contributing economy plus improved performance in industrial parts. Du Pont nylon is unaffected by temperatures up to 250°F., requires little or no lubrication in many moving parts, resists chemical attack, absorbs shock. Perhaps it can help you improve or develop a product. For full information on nylon and other Du Pont plastics, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 214, Du Pont Bldg., Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS



The Kearney Trip Out Open Type Cutouts, Cat. No. 19821 used in the test.

5
KEARNEY
FUSE LINKS
100 AMP.
11100
JAMES R. KEARNEY CORPORATION

Another Feature **HANDY PUL-TAB FUSE PAK**
Plus **COLOR IDENTIFICATION**

The original Kearney protective packaging guards against fuse link damage. Individual waterproof bags prevent tangled wires, make fuse handling easy. To get the right link at the right time simply grasp the clearly marked tab and pull.

Another Kearney first, Color Identification, eliminates fuse link confusion. Each type of Kearney Fuse Link is packaged in a carton printed with its own distinct color combination. This extra feature makes identification almost automatic, prevents errors in reading labels.

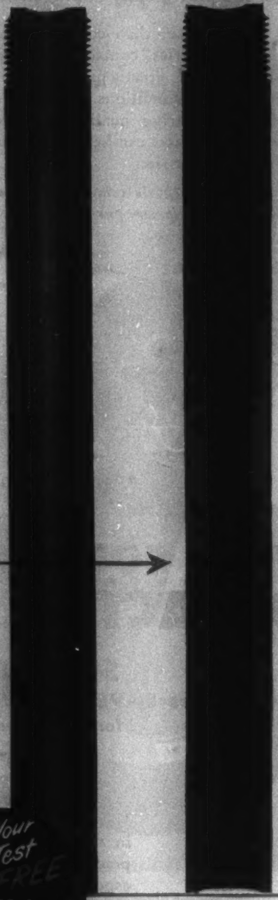
Specify **KEARNEY**

Vol. 72
1953

KEARNEY FUSE LINKS

Prevent Fibre Damage

This simple test proves that Kearney Low Temperature Fuse Links give better system protection. Put a Kearney 100 ampere Type 200 Fuse Link in one cutout and any high temperature fuse link which has about the same continuous current carrying capacity in another. Pass 175 amperes through them for 1 hour and 50 minutes and then melt them with an increased load of 250 amperes. Now, let's look at the results.



LOW TEMPERATURE

This unretouched photograph shows the interior of the cartridge fused with the Kearney Fuse Link. Note the absence of any charring or burning. Original arc extinguishing properties remain unchanged; cartridge could stay in service indefinitely.

HIGH TEMPERATURE

This is the tube used with the high temperature fuse link. Look how most of its surface has been deeply burned, seriously reducing its arc extinguishing ability. This cartridge obviously should be replaced immediately.

WARNING: How many of your cutout cartridges are in this dangerous condition? If you have been using high temperature fuse links and have normal service overloads such as described above, then chances are that most of them look like the tube on the right. Remember, you can't see the damage from the outside, but the charred fibre on the inside will fail to quench the arc on the next operation. Play it safe. For reliable, low temperature system protection, switch to KEARNEY FUSE LINKS.

Make Your Own Test
FREE
One—100 Amp.
Cat. No. 11100
Kearney
Fuse Link

JAMES R. KEARNEY CORPORATION
4224-42 CLAYTON AVENUE • ST. LOUIS 10, MISSOURI
Canadian Plant: Guelph, Ontario

Gentlemen:

Send me a free 100 Amp. low temperature Kearney Fuse Link. I want to make my own test.

Name...
Company...
Address...
City.......................................State.....................
Title...

221

PRODUCTS

for Better Construction — Safer Maintenance

STACKPOLE
SG Series SILVER GRAPHITE FORMULAS
for longer life plus greatly improved contact drop

30% harder than conventional silver-graphite SG series contact materials, Stackpole silver-graphite greatly prolongs contact life under short circuit conditions. Far better contact drop is assured. Wearing qualities are tremendously improved. Contacts can be made in practically any desired shape or size.

NOTE: Stackpole contacts are sold only for electrical equipment purposes.

THEY SOLVE A LOT OF CONTACT PROBLEMS!

STACKPOLE
CW Series SILVER-TUNGSTEN FORMULAS
for high-amperage uses

In many typical cases—from circuit breakers to other heavy-duty equipment—Stackpole CW series silver-tungsten contacts have permitted substantial increases in amperage rating while making it entirely practical to *reduce* the size of equipment. On especially difficult applications, one of these units operating against a Stackpole silver-graphite contact (see above) provides truly outstanding efficiency.

FOR HELPFUL DATA ON CONTACT SELECTION AND USE . . . write for 36-page Stackpole Catalog 12

Stackpole Carbon Company, St. Marys, Pa.

STACKPOLE

Stackpole contact types include: SILVER GRAPHITE; SILVER LEAD OXIDE; SILVER NICKEL; SILVER MOLYBDENUM; SILVER TUNGSTEN; COPPER GRAPHITE; SILVER-COPPER GRAPHITE; GOLD-GRAPHITE; SILVER IRON OXIDE and many special grades

CONTOURED BRUSHES *for*

IMPROVED MOTOR PERFORMANCE
FEWER, FASTER BRUSH CHANGES
LESS MOTOR "DOWN" TIME

because . . .
HELWIG CARBON BRUSHES are "Custom-Bilt" for instant installation . . . .

Cut brush replacement and motor repair to a minimum with Precision-made Helwig brushes—They fit your commutator and rings exactly.

Quality Helwig brushes eliminate uneven wear, reduce sparking and improve brush life.

Write for catalog No. 95 for complete details on types of brushes and grade recommendations for every use.

HELWIG CARBON PRODUCT CO.
2547 N. 30th St., Milwaukee 10, Wisconsin

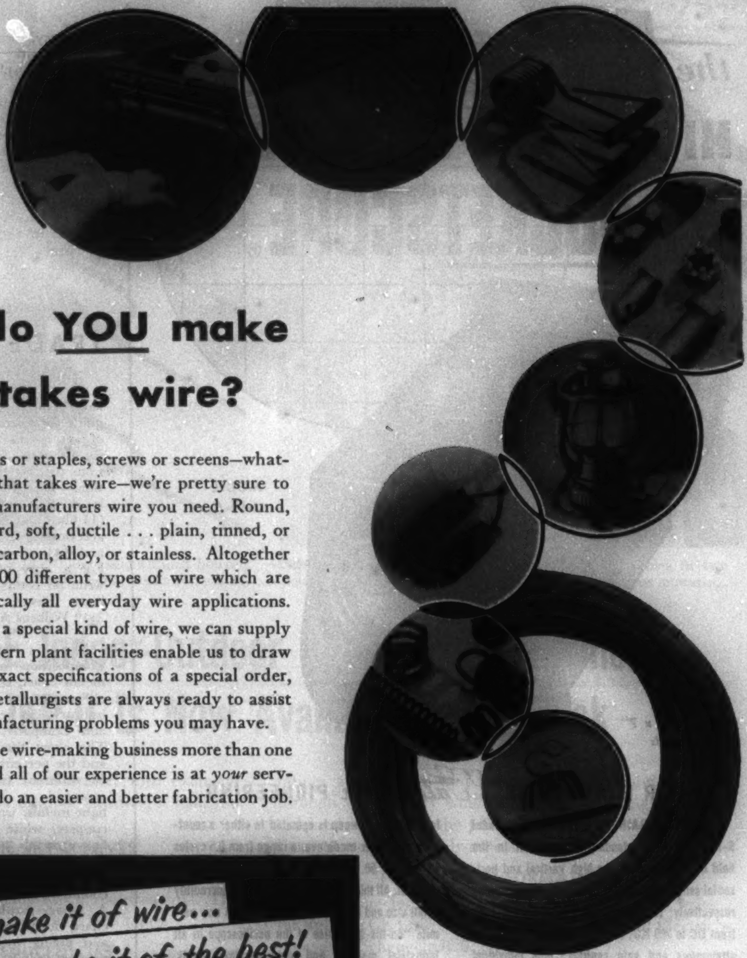
HELWIG SPEER

MINIMIZATION of INTERFERENCE from RADIO-FREQUENCY HEATING EQUIPMENT #951

This report on a recommended practice reviews the theoretical aspects of the interference problem and then outlines procedures which should be followed; which may be applied both in construction and as remedial measures where interference exceeds limits specified in FCC rules. Price $.80; 50 per cent discount to AIEE members. Address:

AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

4-53



What do YOU make that takes wire?

If you make sieves or staples, screws or screens—whatever you make that takes wire—we're pretty sure to have the kind of manufacturers wire you need. Round, flat, square . . . hard, soft, ductile . . . plain, tinned, or bright finished . . . carbon, alloy, or stainless. Altogether we produce over 400 different types of wire which are suitable for practically all everyday wire applications.

But, if you need a special kind of wire, we can supply that too. Our modern plant facilities enable us to draw wire to meet the exact specifications of a special order, and our trained metallurgists are always ready to assist you with any manufacturing problems you may have.

We've been in the wire-making business more than one hundred years, and all of our experience is at *your* service . . . to help you do an easier and better fabrication job.

If you make it of wire...
make it of the best!

U·S·S AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

USS

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

the Waterman

HIGH GAIN INDUSTRIAL POCKETSCOPE®

MODEL
S-14-A

Size:
12″ x 5¾″ x 7″
12¾ Pounds

ANOTHER EXAMPLE OF Waterman PIONEERING . . .

The HIGH GAIN POCKETSCOPE, model S-14-A, is an outstanding achievement in the field of oscilloscopes. The high vertical and horizontal sensitivities of 10 and 15 millivolts rms/inch respectively; frequency responses within —2 db from DC to 200 KC; non-frequency discriminating attenuators and gain controls; plus individual calibration voltages are but a few of the heretofore unobtainable characteristics of DC coupled oscilloscopes. The sweep is operated in either a repetitive or trigger mode over a range from 0.5 cycles to beyond 50 KC with synchronization polarity optional. All this and portability too! The incredibly small size and light weight of the S-14-A now permits "on-the-spot" use of the oscilloscope in all industrial, medical, and communications fields. Its rugged construction assures "laboratory performance" regardless of environment.

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

MEMO... Write for details today!

WATERMAN PRODUCTS INCLUDE

S-4-A SAR PULSESCOPE®
S-5-A LAB PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE
S-12-B JANized RAKSCOPE®
S-14-B HIGH GAIN POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE

Also RAYONIC® Cathode Ray Tubes and Other Associated Equipment

WATERMAN PRODUCTS

(Continued from page 58A)

frequency, three banks of 10 push-button switches are provided. An additional vernier control varies the frequency continuously by an amount equal to the increment between adjacent buttons of the third switch bank. Hum and distortion are attenuated when the setting of the calibrated logarithmic output level control is reduced and are maintained at a constant low percentage of the desired output signal. This instrument is suited for bridge measurements, tuned filter alignment, rapid spot frequency checks, and distortion measurement.

TRADE LITERATURE

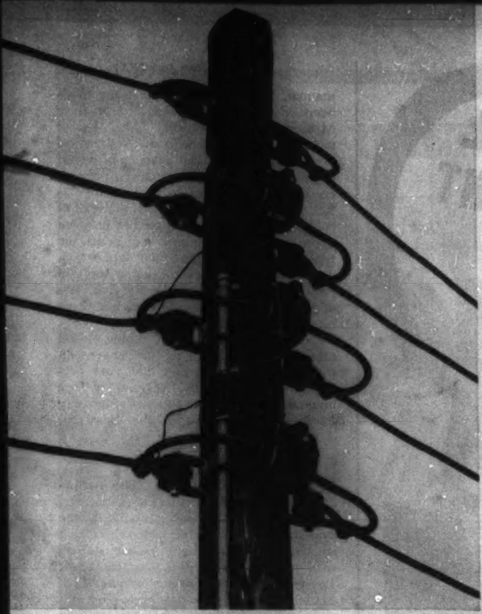
Industrial X-Ray Catalogue. A buying guide for a complete and diversified line of accessories and supplies required for the industrial X-ray installation is available from the Westinghouse Electric Corporation. This 44-page illustrated catalogue is divided into four basic categories: (1) films and chemicals; (2) radiographic accessories; (3) darkroom accessories; and (4) viewing and filing equipment. For a copy of this catalogue, *404-000*, write on company letterhead to Westinghouse Electric Corporation, Section X, 2519 Wilkens Avenue, Baltimore 3, Md.

Composition of Industrial Metals. A metals chart, showing the compositions of all commonly used metals and alloys in industry, has been prepared by Sam Tour and Company, Inc., New York, N. Y. The chart lists the constituent elements and the percentage composition ranges for 60 different classes or types of metals arranged in the following groupings: light metals, irons, steels, cobalts, nickels, coppers, white metals, precious metals, heavy metals, and special-purpose metals. Also shown is the atomic number and specific gravity of each of the 48 elements commonly encountered in industrial metals. A 2-page explanation accompanies the chart, describing the purpose of the chart and giving useful definitions of various types of metals. Copies may be obtained upon request to Sam Tour and Company, Inc., 44 Trinity Place, New York 6, N. Y.

Viking Catalogue. A new 16-page catalogue of Viking Electric, 1061 Ingraham Street, Los Angeles 17, Calif., has been completed. This loose-leaf catalogue gives engineering specifications and templates of miniature connectors, terminal boards, thermocouple connectors, and printed circuit hardware. Write to Department M, Viking Electric, 1061 Ingraham Street, Los Angeles 17, Calif., for a free copy.

Industrial Temperature-Control Manual. The Partlow Corporation, New Hartford, N. Y., has published a new edition of its

(Continued on page 66A)



OUTDOOR INSTALLATIONS of JKP-0 are made without housing or cross-arms—due to low-cost, rugged butyl insulation-casing.

INDOOR VIEW shows insertion of two primary cables in two inch window. Secondary terminals on top permit close mounting.

1878 75 1953 YEARS OF ELECTRICAL PROGRESS

New G-E Indoor-Outdoor Current Transformer Type JKP-0 Is Now Available from Stock

The new JKP-0 current transformer, with exclusive butyl-insulation and indoor-outdoor features, is available from stock.

4 WAYS THE JKP-0 SAVES

1. STOCKING COSTS REDUCED: Standardizing on the JKP-0 cuts costs by reducing stock requirements. This versatile new transformer replaces 5 G-E types.

2. MAINTENANCE IS REDUCED: JKP-0 transformers will not corrode and need no painting—due to rugged butyl-molded construction.

3. INSTALLATION COST IS LESS: The JKP-0 does not require elaborate arrangements of cross-arms, hanger, connections, etc.—and the amount of wiring is reduced.

4. INITIAL COST IS LESS: The JKP-0 sells for less than most of the conventional types it replaces.

FOUR RATINGS AVAILABLE

Four current ratings are available in the Type JKP-0. They are 200:5, 400:5, 600:5, and 800:5 amperes. These ratings are obtained by passing the line conductor once through the primary window. Additional ratings can be obtained by looping the primary conductor two or more times through the easily-accessible window.

FOR MORE INFORMATION

Contact your local G-E representative today, or write for Bulletin GEA-5874 to Section 604-37, General Electric Company, Schenectady 5, New York.

You can put your confidence in—

GENERAL ELECTRIC

1953
EDITION
NOW
AVAILABLE

FREE—SEND TODAY

General Electric Company, Sec. 604-37
Schenectady 5, New York

Please rush my copy of the new 1953 INSTRUMENT TRANSFORMER BUYER'S GUIDE (GEA-4626).

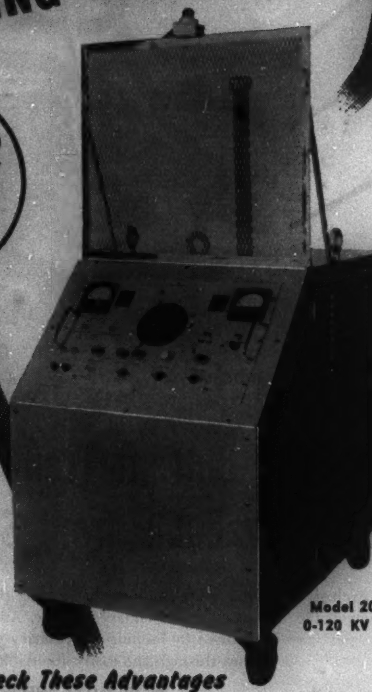
( ) Planning immediate project
( ) Reference

Name............
Position............
Company............
Street............
City............ State............

DC OVERPOTENTIAL TESTING EQUIPMENT

DESIGNED & BUILT BY BETA

STANDARD MODELS
0-30 KVDC—series 201
0-50 KVDC Model 2008B
0-120 KVDC Model 2047
Special Models to Meet Individual Requirements



Model 2047
0-120 KV DC

Check These Advantages

- The voltages which are equally searching for defects and physical damage are far less damaging than the equivalent a-c voltages.
- The slope of the voltage endurance curve is such that the time of voltage application is not nearly so critical with d-c as with a-c.
- The problems associated with d-c testing of large equipment are far simpler, as a testing device with limited capacity can be used. Therefore, the d-c tester is a small, relatively portable device which can utilize any convenient power supply.
- The use of the d-c test voltages required will give assurance that the insulation has passed a voltage test which can be coordinated with conventional machine lightning arrester protection.

Field Engineers Throughout the Country to Discuss Your Applications

BETA Electric Corporation
333 East 103rd St. • New York 29
ENright 9-8520

(*Continued from page 64A*)

manual, "The Design and Process Engineers Guide to Industrial Temperature Measurement and Control." This 24-page manual, available without charge to process engineers, plant managers, design engineers, and heating engineers, presents the basic principles of industrial temperature control. It defines different types of control systems and distinguishes between them so that the engineer can select the type most suited to a particular application. The manual discusses the eight ways of responding to temperature; the five ways of putting that response to work; and the nine basic Partlow instrument types. Typical control circuits and piping system arrangements, as well as the ranges and calibrations of scales and dials, are presented diagramatically. Copies of the manual, *101*, may be obtained from any Partlow representative or the factory.

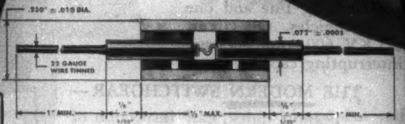
Magnetic Motor Starters. The Arrow-Hart and Hegeman Electric Company, Hartford, Conn., has announced the availability of an 8-page folder describing its type *RA-V* magnetic motor starters with vertical overloads below contactor. The right-angle mechanism of type *RA-V* combines small size and light weight with added dependability. This combination provides savings in four ways: smaller, lower-cost condulets; faster, easier installation; reduced size and cost of mounting racks; and lower building costs and space requirements. The folder is fully illustrated and includes design features, size and weight data, and other information of interest to the engineer. It is available from the manufacturer, The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn.

Automotive Welding Repair Manual. Designed primarily as an aid to salvage of all truck and car equipment is a manual, "Truck and Car Fleet Maintenance and Repair Welding Manual," offered free of charge by the Eutectic Welding Alloys Corporation, Flushing, N. Y. Over 86 step-by-step photographs, plus 25 diagrams and charts, in this 56-page book illustrate money-saving ways to add years of service life to any automotive vehicle. Contents include repair of all stationary and operative parts grouped under these major headings: salvaging truck and automotive castings; repairing functional and mechanical parts; saving cracked and damaged body parts; salvaging ornaments, accessories, and auxiliary equipment. Welding, brazing, and soldering techniques are detailed for all steels, cast iron, cast and sheet aluminum, brass, bronze and copper, zinc die cast, magnesium, monel, and nickel. Repairs on motor, head, block and manifold, cooling and heating systems, bumpers, transmission gears and shafts, frame and spring, body, fender, shaft overlays, steering and suspension links, and others are discussed. Requests for copies should be addressed to Department P, Eutectic Welding Alloys Corporation, 40–40 172d Street, Flushing 58, N. Y.

INTERNATIONAL RECTIFIER
CORPORATION

EL SEGUNDO
CALIFORNIA

Germanium Diodes



Features:

1. Ruggedized construction
2. Welded anchor pins
3. Triple moisture protection
4. Self-insulating case
5. Vibration resistant
6. Shock resistant
7. Higher efficiency
8. Stability of characteristics
9. No flaking

All types available for prompt shipment

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Chicago Branch Office: 205 West Wacker Drive • Phone: Franklin 2-3889
New York Branch Office: 12 West 32nd Street, N. Y. 1 • Phone: Chickering 4-0017

THE MODERN STANDARDIZED, VERTICAL LIFT, METAL-CLAD OIL CIRCUIT BREAKER SWITCHGEAR

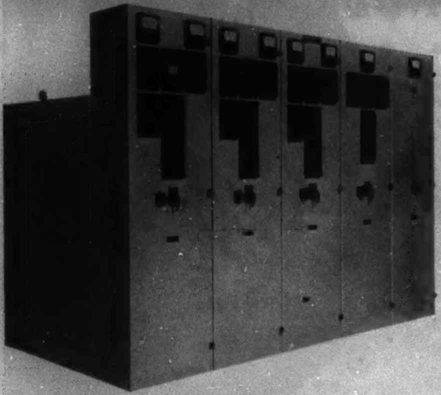
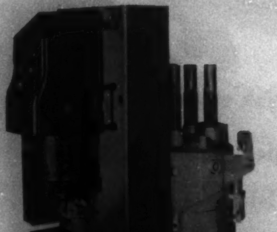


Photo shows assembly of three motor starting, one incoming line and one auxiliary feeder cubicles. Oil circuit breakers are 5 KV, 600 Amp, 3 Phase, 100 MVA interrupting capacity.

2300, 4160, 4800, 7200 & 13,800 VOLTS
50 TO 500 MVA INTERRUPTING CAPACITY
600 — 1200 AMPERES CONTINUOUS
INDOOR OR OUTDOOR CONSTRUCTION

THE MODERN SWITCHGEAR —

— permits quick, easy inspection of oil circuit breaker contacts and mechanism. Just remove tank nuts and elevate breaker out of tank.



THE MODERN SWITCHGEAR—

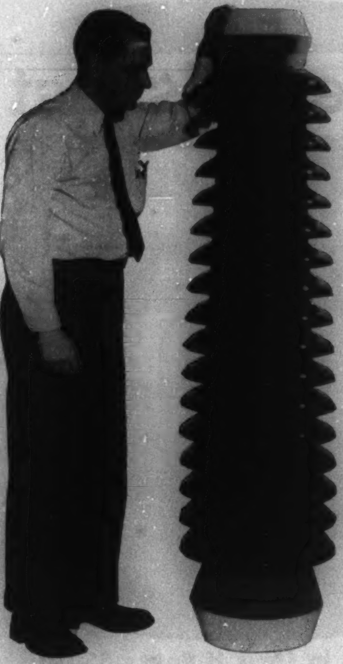
— has oil circuit breaker mounted on truck which eliminates transfer dollies and test stand — utilizes maximum benefits of drawout construction. Closing relays, rectifiers and related apparatus are all mounted on withdrawable truck.

STANDARD BASIC UNITS

1. Swinging instrument panel
2. Generator
3. Exciter for generator
4. Totalizing
5. Incoming supply
6. Feeder
7. Induction motor — full voltage starting
8. Induction motor — reduced voltage starting
9. Synchronous motor—full voltage starting
10. Snychronous motor—reduced voltage starting
11. Bus sectionalizing
12. Blank unit
13. Auxiliary compartment — miscellaneous equipment
14. Bus entrance compartment
15. Air or oil isolator

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

217 N. DETROIT AVE. TELEPHONE 2-5131



THIS IS A 161-Kv POTHEAD BUSHING

This porcelain bushing is part of the terminal for a high-pressure oil-filled cable. Manufactured to Lapp standards of strength, soundness and close dimensional tolerance, it becomes part of a substantially improved device for its purpose.

In service, it operates under 200 lbs.-per-sq.-in. pressure. To assure an adequate factor of safety, each piece is tested at 500 lbs. pressure. Thermal tests are made under pressure.

A critical requirement in the design, and tolerance of manufacture, of this piece is that it be leakproof under this pressure—and that a mechanical seal be effected in such a way as not to harm the porcelain through its years of service, under sharp thermal changes or the mechanical loads involved.

Ceramic pieces of large size and of close dimensional tolerance are traditionally difficult of production. Yet Lapp has a long record of successful performance in meeting such requirements. The reason lies in Lapp's history of dissatisfaction with existing "bests" . . . in Lapp's zealous pursuit of improved knowledge in design, production techniques and controls.

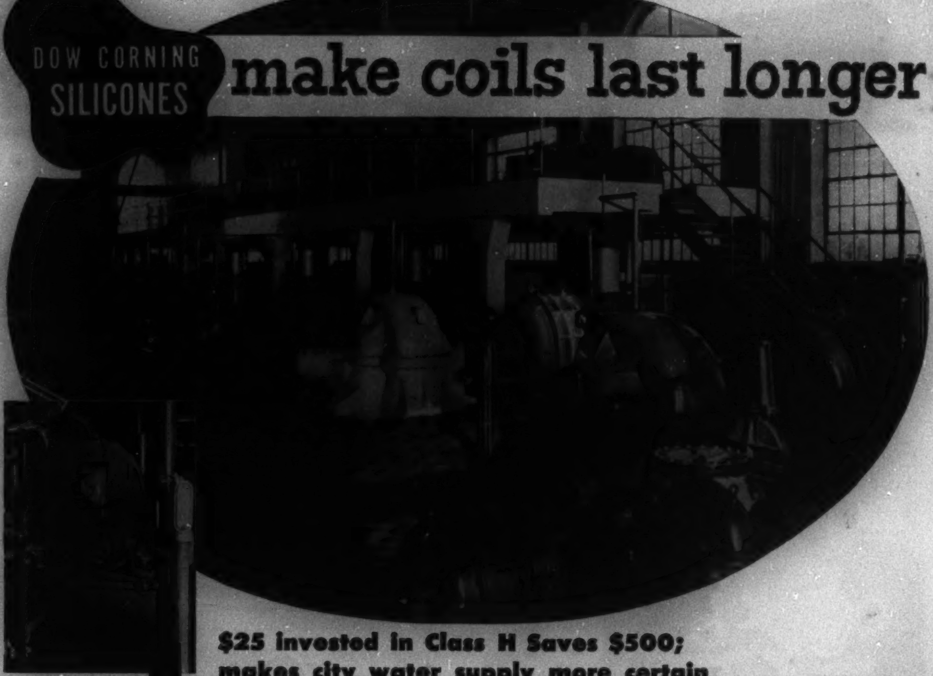
For porcelain pieces of special design, or routine pieces with something "special" in the way of extra performance, look for the name LAPP. Manufacturers of equipment incorporating electrical porcelain—as well as users of high voltage insulators—know that although *you can buy cheaper porcelain—you can't buy better porcelain—than Lapp.*

Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp

DOW CORNING
SILICONES

make coils last longer



$25 invested in Class H Saves $500; makes city water supply more certain

Half of Philadelphia's water supply is handled through the Torresdale Raw Water Pumping Station by six 60,000,000 gallon per day centrifugal pumps driven by 2300 volt, 500 hp motors. These motors are controlled by oil filled circuit breakers. Trouble was that the circuit breaker coils had an average life of only 3 months; cost the taxpayers $50 every time a new coil was installed.

So to save taxpayers' money and secure more continuous and reliable operation of pumping equipment, department engineers had these coils rewound with Class H insulation at an additional cost of $25 per coil. That was 30 months ago. Not a single coil has failed to date, and that's already 10 times the average life of previous coils. Represents a saving of $500 per coil; a net saving so far of $3000 less the original investment of $150.00 in Class H or $2850.

That's the kind of performance and the brand of economics that has persuaded a steadily increasing number of engineers and top management men to specify Class H insulation made with Dow Corning Silicones. In thousands of applications from subminiature electronic circuits, through traction motors, generators and transformers to industrial motors ranging from 1/8 to 1000 hp, Class H insulation has given 10 to 100 times the life of comparable equipment built with the next best class of insulating materials.

Increase efficiency; cut production and maintenance costs; specify silicone (Class H) insulation.

NOTE: New Dow Corning Silicone Resins are now available to give you unequalled freedom in design—still more power per pound—even longer life and greater dependability. Write for data on the new Dow Corning 994 Varnish for coating; Dow Corning 997 Varnish for impregnating; and Dow Corning 2105 Resin for bonding.

mail this coupon *Today!*

DOW CORNING CORPORATION, Dept. H-4, Midland, Michigan

Please send me:

☐ Performance data on Class H equipment
☐ List of Class H Rewind Shops
☐ Data on Dow Corning 44 Grease for bearings
☐ Data on Dow Corning 994 Varnish
☐ Data on Dow Corning 997 Varnish
☐ Data on Dow Corning 2105 Resin

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ALLIS-CHALMERS
5/8% STEP
VOLTAGE REGULATORS

Get Voltage Regulation at Low Cost

With All 32-Step Regulator Advantages

HERE'S THE ANSWER to your voltage problems. Allis-Chalmers distribution regulators are low in cost. They are easy to install, simple to maintain. And they give *all* the advantages of Allis-Chalmers ⅝% step regulation: a narrow ± 1 volt band, 20% range of regulation, long-life contacts, and *Feather-Touch* control.

In addition, Allis-Chalmers distribution regulators have proved their reliability in eight years of field operation. Experience has also proved another major advantage: they are flexible. Their ease of installation and setting makes it easy to shift them from feeder to feeder.

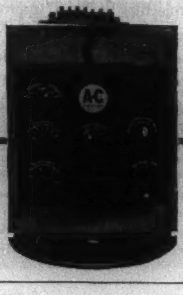
Get all the facts on these low cost units. Call your nearest A-C district office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3882

RATINGS AVAILABLE	*7620 Volts—15, 50, 100 amp* *5000 Volts—50, 100 amp* *2500 Volts—100, 200 amp*

Feather-Touch *Control Simplifies Installation*

There's just one adjustment to make when installing — set the calibrated voltage level. For more facts, write for Bulletin 01M7866-1.

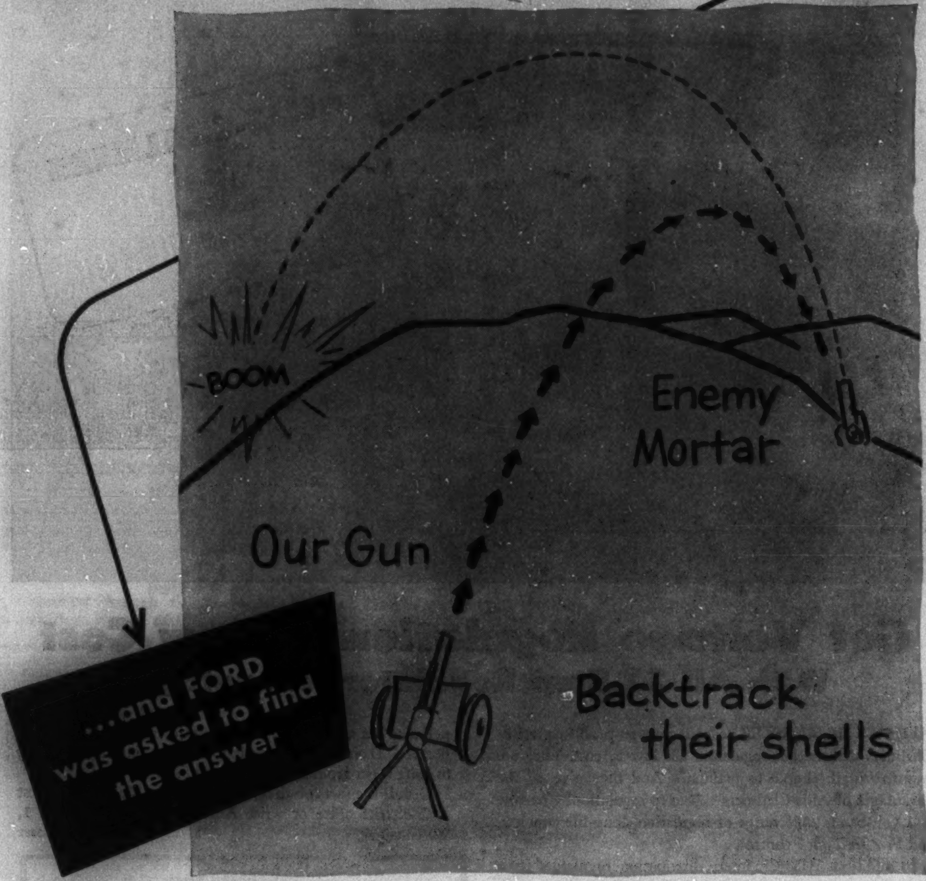


ALLIS-CHALMERS A-C ALLIS-CHALMERS

Originators of ⅝% Step Regulation

TO BACKTRACK SHELL TO GUN

and destroy same



Can projectiles be "seen" approaching and their flight backtracked to locate the mortar or gun that fires them? This problem was simply reconciled with special computing equipment designed to be built right into the gun. The engineering of such a computer, the handling of such ballistic data, all falls into the pattern of previous Ford achievements.

This is typical of the problems that Ford has solved since 1915. For from the vast engineering and production facilities of the Ford Instrument Company, come the mechanical, hydraulic electro-mechanical, magnetic and electronic instruments that bring us our "tomorrow" today. Control problems of both Industry and the Military are Ford specialties.

6

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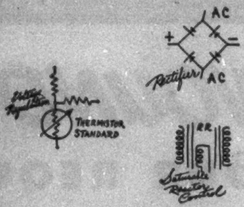

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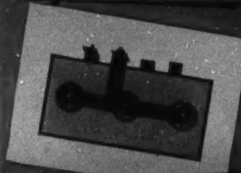

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SUBMINIATURE TYPE
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Input current	140 ma max.
Input impedance	61 /77° ohms
Secondary voltage	23.2 ± 1 v
Total null voltage	40 mv max.
Fundamental Component of Null voltage	30 mv max.
Time Phase Shift	7°
Moment of Inertia	8.8×10^{-5} slug in^2
Frictional Torque	.05 oz. in.
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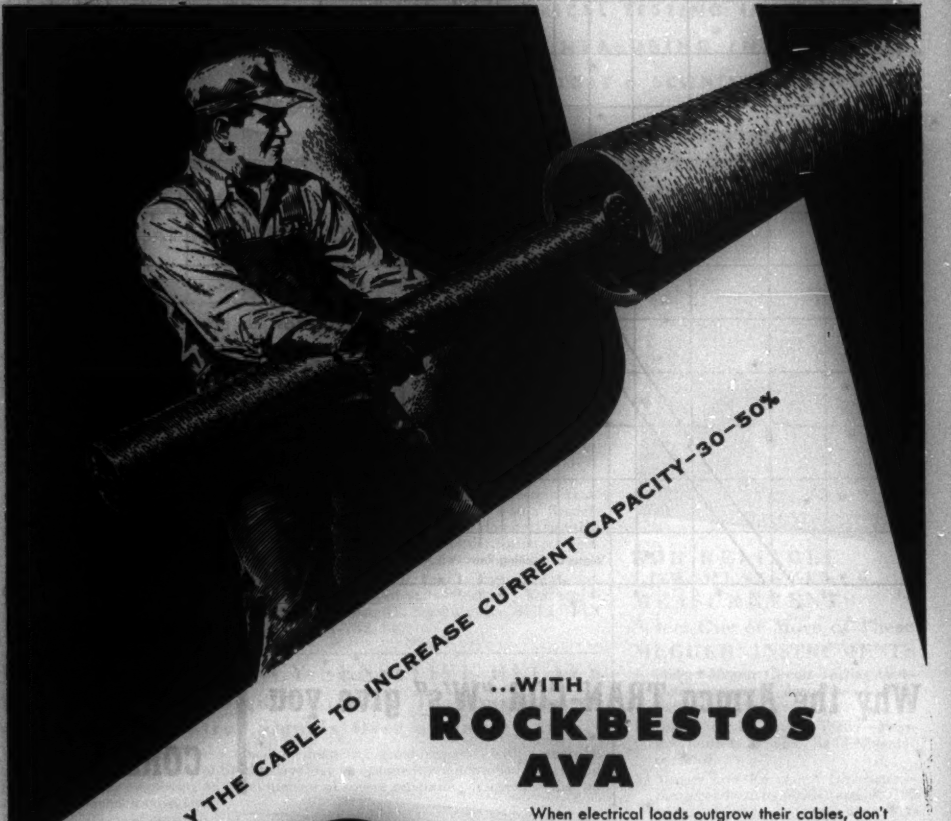

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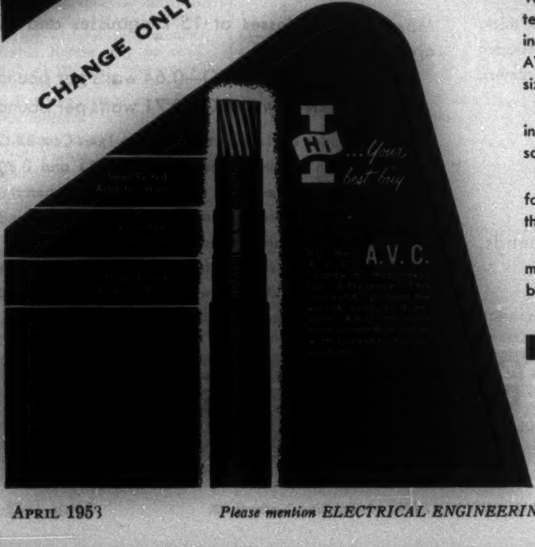

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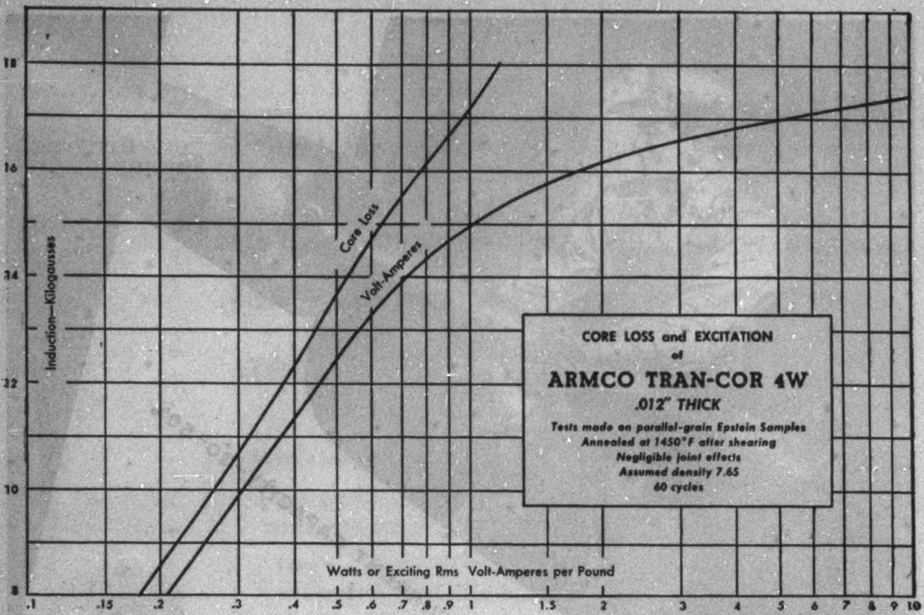

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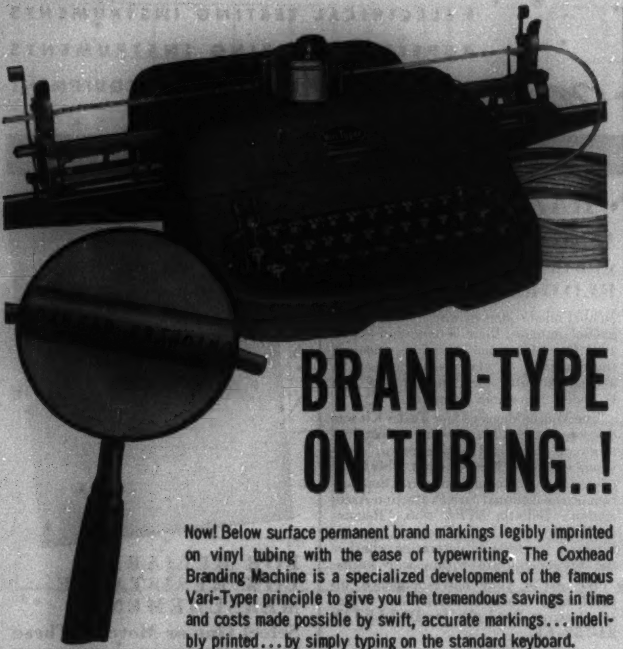

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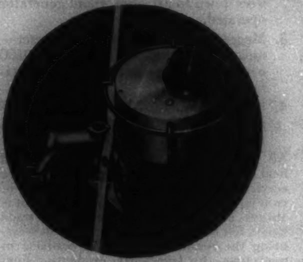

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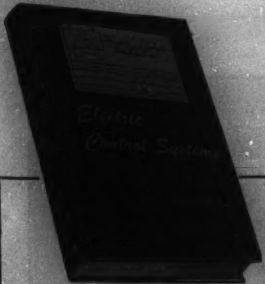

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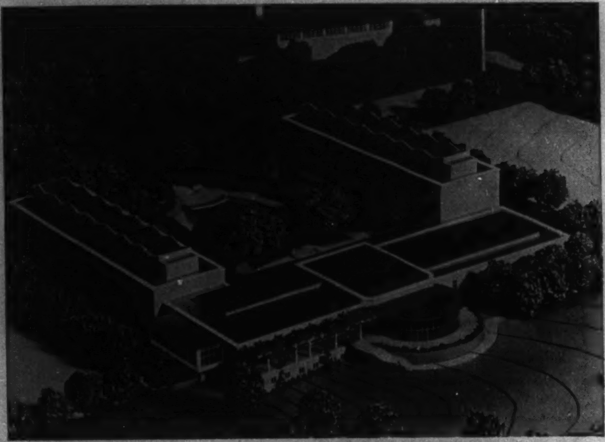

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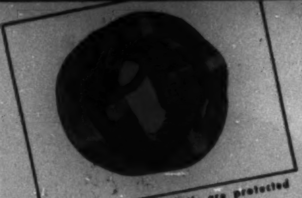

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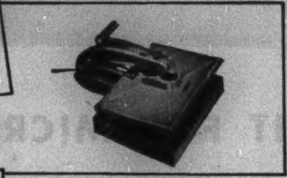

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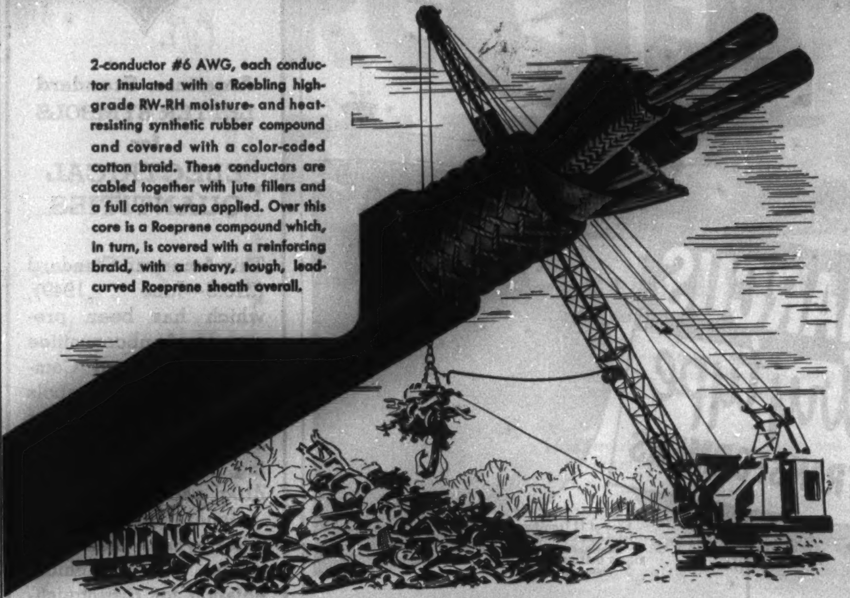

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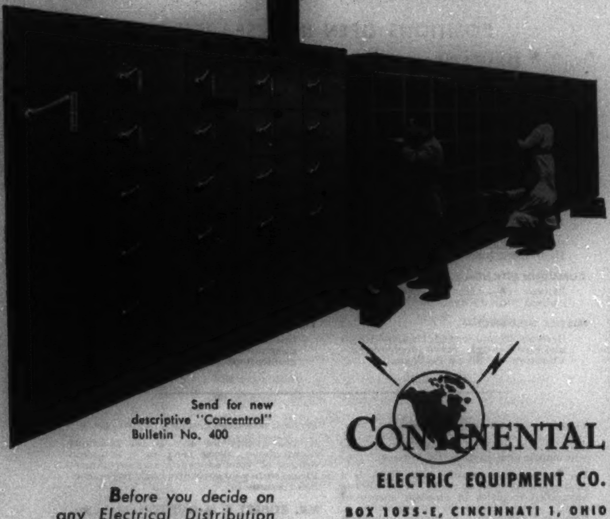

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Power Supply for Resistance Welding Machines
(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940–1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

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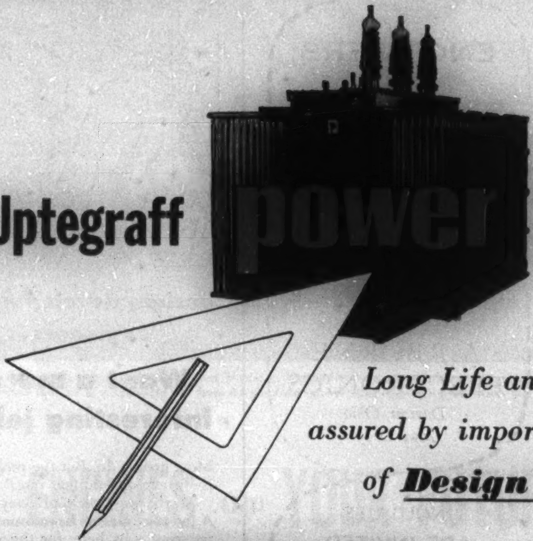

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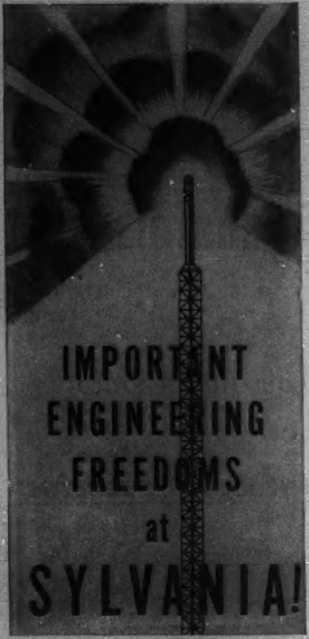

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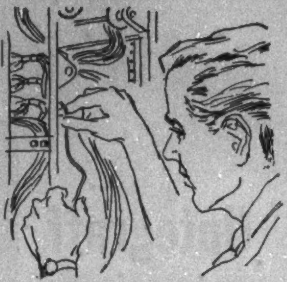

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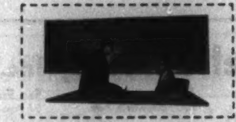

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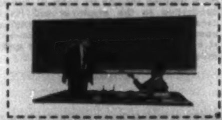
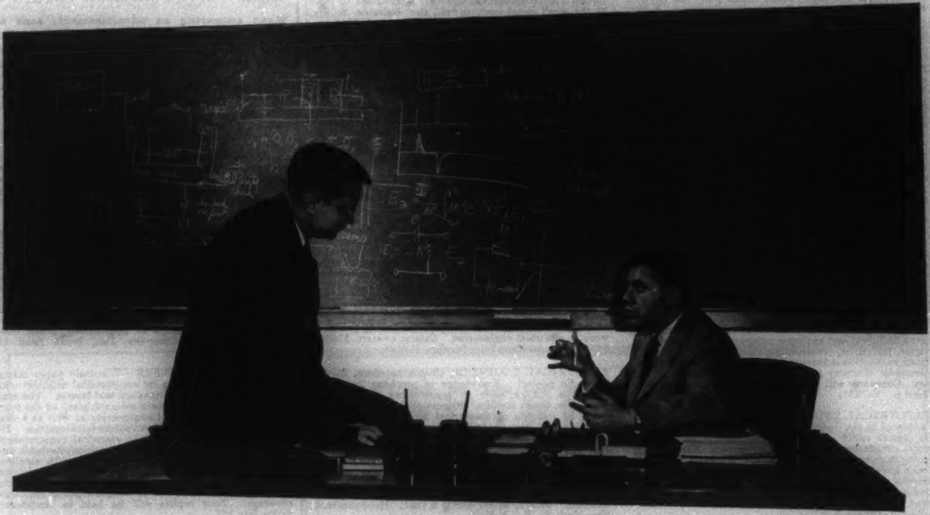


The complexity of modern air defense—extreme aircraft speeds, highly complex weapons, new combat strategies, the advanced state of today's technology—poses serious problems for the scientist and engineer.



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Dr. E. C. Nelson (left), Head of Computer Systems Department, and J. H. Irving, Head of Systems Planning and Analysis Department, discuss a problem in the systems planning and analysis stage.

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SALES ENGINEER, ELECTRICAL ENGINEERS, PHYSICIST, PRODUCTION MANAGER—1. Sales Engineers with E.E. degree and 5 years capital goods selling experience. Knowledge of paper, plastics or rubber industry helpful. 2. Senior Project Engineer with E.E. degree and 5 years' experience in direction of design projects for industrial electronic, servo-mechanism, or radar equipment. 3. Senior Research Engineer with Ph.D. or equivalent in physics or engineering and 5 years' experience in direction of radiochemistry, physics and electronic systems analysis. 4. Production Manager with engineering degree and 5 years' experience in supervision of electronic and mechanical production including production and materials planning. Salaries open. Send complete resume. Write Box 360.

ASSISTANT IN ADVERTISING AND SALES PROMOTION DEPARTMENT of progressive manufacturer of electric power apparatus. Graduate electrical engineer with some industrial advertising experience wanted. Job involves planning and production of technical and promotional publications on application of large motors, generators and control. Salary commensurate with ability and experience. Location—Minneapolis, Minnesota. Write Box 356.

SALES ENGINEER, age 25–40, some technical background desirable, to call on utility industry in midwest-southwest states from Chicago office of long established cable company. Permanent position, salary and expenses. State age, education, experience, references, salary. Write Box 388.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY'S DIGITAL COMPUTER LABORATORY OF THE DEPARTMENT OF ELECTRICAL ENGINEERING needs some experienced electronic engineers and a mechanical engineer in developing high-speed electronic digital equipment (vacuum-tube and magnetic-core circuitry, and mechanical design and packaging to make equipment suitable for production). There is also work on use of high-speed digital computers to control large physical systems. This involves study of control requirements of the whole system, reduction of them to a simple pattern of control instructions, and translation of the pattern into computer code. Position requires appreciation for physical systems, ingenuity, and imagination. Training in computer principles provided as necessary. Persons from other fields wishing experience in digital computers for engineering and military uses are encouraged to apply and may come on leave from their permanent organizations. Position carries opportunity for academic study. Salary appropriate to candidate's experience and training. 211 Massachusetts Avenue, Cambridge, Mass.

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REGISTERED ELECTRICAL ENGINEER, Ph.D., 4 years teaching experience, 12 years other professional experience. Wants permanent teaching position or research, preferably nondefense. Prefer West or Middlewest. Write Box 380.

ELECTRICAL ENGINEER, BSME, MSEE, age 37, European trained, U. S. citizen. 12 years' experience in development and design of magnetic amplifiers, transductors (d-c current transformers), measurement of dynamic hysteresis loops, hydro-magnetic servosystems, magnetic pulse generators, ultrafast flux-blocking relays, permanent magnet systems, special chokes and transformers, commutating reactors, analysis of networks with essentially nonlinear components, mechanical rectifiers. Experience in training young engineers and co-ordinating the work of specialists from different fields. Experience in supervising complicated large size installations. Cleared for classified work familiar with patents. Fluent French and German. Write Box 381.

SALES ENGINEER, B.S.E.E., registered professional engineer, age 35, married. 10 years design and application experience with associated sales responsibilities in switchgear, control and allied equipment. 3 years sales and business administration. Desires to become associated with well rated established manufacturer, for representation in Milwaukee and Wisconsin area. Good appearance and pleasing personality. Best of references available. Write Box 382.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the first of the month preceding issue; i.e., July first for August issue.

ELECTRICAL ENGINEER, B.S.E.E., 26, married, one child, Veteran. Recently completed 1½ years of G.E. Test program. Desires permanent Western location. Write Box 383.

MATHEMATICIAN, B.S.E.E., M.A. in Mathematics. Experienced college teacher seeks advancement in teaching or digital computer research. Write Box 384.

ELECTRICAL ENGINEER, B.S.E.E., 31, 2½ years' experience in power plant construction. Desire permanent position in design and construction. Write Box 385.

RESEARCH ENGINEER, 50, B.S., M.S. in Electrical Engineering, 28 years varied experience in management, research, development in electrical and mechanical instruments, sound recording, industrial electronics, battery research, oxygen manufacture, etc. Record of achievement with 23 patents granted, 5 applications over forty million dollars of products resulting. Desires opportunity for inventive activity or supervision of research or development. Locations preferred: South, middle East, Pacific. Available May 1. Write Box 386.

ELECTRICAL ENGINEER, B.S.E.E., M.S.E.E., Registered, 43, married. 10 years Public Utility, distribution and transmission engineering—cost estimating, layout, and construction. 10 years teaching power and transmission courses at large university. Also network calculator experience. Desires responsible position in Public Utility or teaching. Write Box 387.

ELECTRICAL ENGINEER, B.S. in E.E.; age 25, four years in design and supervision of electrical systems in commercial, industrial, and public buildings. Seeking part-time employment in evening for consulting engineer or architectural firm in design of interior electrical systems for buildings. Location New York City. Write Box 389.

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Priced at $1.00 ($0.50 to AIEE members), publications S-35 (February 1950) is available from the Order Department,
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS,
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4-53

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The Federal Communications Commission, in cooperation with the Technical Cooperation Administration of the Department of State, is recruiting to fill positions in its Technical Cooperation Administration Point IV Mission in Tehran, Iran. The filling of these positions will provide for the administration and direction of various transportation and communications programs, and serve to assist in the development of the Postal, Telephone and Telegraph systems of Iran. Salaries range from $5,000 for technicians to $11,000 for experts of established reputation and authority. This scale, however, is not inflexible and is cited merely to give an idea of the possible remuneration for foreign service positions. Future requests are anticipated for positions of this nature in countries of the East and Near East and applications are welcome from anyone expressing an interest in foreign service.

Interested applicants may obtain Civil Service Commission forms SF-57 on which to apply, from most post offices or by writing direct to either the Civil Service Commmission or the Federal Communications Commission, Washington 25, D. C. Forms should be submitted in duplicate to: Federal Communications Commission, Technical Assistance Division, Room 7513 New Post Office Building, Washington 25, D. C.

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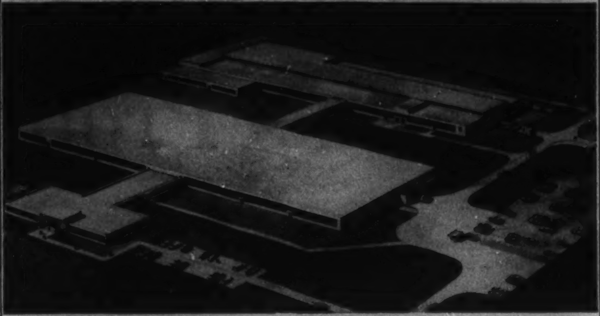

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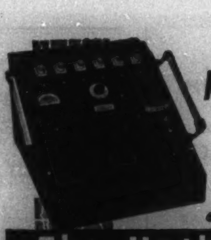

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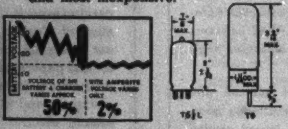
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INDEX TO ADVERTISERS

AC Spark Plug Division .... 95 A
Acme Electric Corp. .... 46 A
AIEE Special Publications 45 A, 80 A, 88 A, 96 A, 96 A, 101 A
Allen-Bradley Co. .... 31 A–32 A
Allis-Chalmers Manufacturing Co. .... 2nd cover, 27 A, 36 A–37 A, 71 A
Amana Refrigeration, Inc. .... 96 A
American Steel and Wire Division .... 63 A
Amperite Co., Inc. .... 102 A
Anderson Brass Works, Inc. .... 43 A
Armco Steel Corp. .... 78 A
Arnold Engineering Co., The .... 73 A
Askania Regulator Co. .... 98 A
Bell Telephone Laboratories .... 26 A
Beta Electric Corp. .... 66 A
Biddle Co., James G. .... 79 A
Boeing Airplane Co. .... 97 A
Cannon Electric Co. .... 42 A
Classified Advertising .... 94 A–95 A
Cole Electric Co. .... 104 A
Continental Electric Equipment Co. .... 88 A
Cornell Aeronautical Lab., Inc. .... 101 A
Cottrell Paper Co. .... 46 A
Coxhead Corp., Ralph C. .... 80 A
Curtis Development & Manufacturing Co. .... 46 A
Daystrom Instrument Division .... 100 A
Dow Corning Corp. .... 70 A
Du Pont de Nemours and Co., Inc., E. I. .... 59 A
Eagle Pencil Co. .... 39 A
Ebert Electronics Co. .... 40 A
Electric Regulator Corp. .... 22 A
Electric Service Manufacturing Co. .... 29 A
Elliott Co. .... 10 A–11 A
Enterprise Galvanizing Co. .... 42 A
Fast & Co., John E. .... 45 A
Ferranti Ltd. .... 9 A
Ford Instrument Co. .... 72 A
G&W Electric Specialty Co. .... 53 A
General Electric Co. .... 41 A, 65 A, 91 A
General Radio Co. .... 3rd cover
Gibson Electric Co. .... 84 A
Graphite Metallizing Corp. .... 30 A
Hathaway Instrument Co. .... 101 A
Helwig Carbon Product Co. .... 62 A
Henschel & Co., Inc., John .... 18 A
Hevi Duty Electric Co. .... 28 A
Hughes Research & Development Laboratories ... 90 A, 93 A
Ilsco Copper Tube and Products, Inc. .... 30 A
Industrial Notes .. 18 A, 22 A, 28 A, 34 A, 52 A, 58 A, 64 A, 66 A
International Business Machines .... 82 A
International Rectifier Corp. .... 67 A
I-T-E Circuit Breaker Co. .... 56 A–57 A
Jack & Heintz, Inc. .... 96 A
Johns-Manville .... 48 A
Kaiser Aluminum and Chemical Corp. .... 23 A, 51 A
Kearney Corp., James R. .... 60 A–61 A
Kellogg Switchboard & Supply Co. .... 40 A
Kerite Co., The .... 13 A
Ketay Manufacturing Corp. .... 76 A
Lapp Insulator Co. .... 69 A
Leeds & Northrup Co. .... 4 A
Lenkurt Electric Co., Inc. .... 101 A
Locke Department of the General Electric Co. .... 14 A–15 A
Marcus Transformer Co., Inc. .... 86 A
Measurements Corp. .... 45 A
Mechanical Industries Production Co. .... 84 A
Milwaukee Transformer Co. .... 54 A
Minneapolis-Honeywell Regulator Co. .... 90 A
National Carbon Co. .... 2 A, 47 A
National Electric Coil Co. .... 103 A
Nelson Electric Manufacturing Co. .... 68 A
North American Aviation, Inc. .... 100 A
Ohio Brass Co. .... 33 A
Ohmite Manufacturing Co. .... 44 A
Okonite Co., The .... 5 A, 24 A–25 A
Personnel Service, Inc. .... 94 A
Philco Corp. .... 83 A
Phillips Petroleum Co. .... 101 A
Power Equipment Co. .... 74 A
Professional Engineering Directory .... 92 A
Radio Corporation of America .... 4th cover, 87 A
Research Corp. .... 30 A
Rockbestos Products Corp. .... 77 A
Roebling's Sons Corp., John A. .... 85 A
Roller-Smith Corp. .... 35 A
Rome Cable Corp. .... 20 A–21 A
S & C Electric Co. .... 6 A–7 A
Sandia Corp. .... 98 A
Shallcross Manufacturing Co. .... 49 A
Simplex Wire & Cable Co. .... 16 A
Sorgel Electric Co. .... 50 A
Sperry Products, Inc. .... 95 A
Sprague Electric Co. .... 55 A
Square D Co. .... 17 A
Stackpole Carbon Co. .... 62 A
Standards—AIEE .... 38 A, 42 A, 54 A, 62 A, 74 A, 86 A
Standard Transformer Co., The .... 38 A
Stoddart Aircraft Radio Co., Inc. .... 52 A
Struthers-Dunn, Inc. .... 34 A
Sverdrup & Parcel, Inc. .... 96 A
Sylvania Electric Products, Inc. .... 90 A
Syntron Co. .... 74 A
United States Rubber Co. .... 12 A
United States Steel Corp. .... 63 A
Universal Clay Products Co., The .... 40 A
Uptegraff Manufacturing Co., R. E. .... 89 A
Victor Insulators, Inc. .... 19 A
Waterman Products Co., Inc. .... 64 A
Westinghouse Electric Corp. .... 58 A, 81 A, 99 A
Weston Electrical Instrument Corp. .... 8 A
Wiley and Sons, Inc., John .... 82 A

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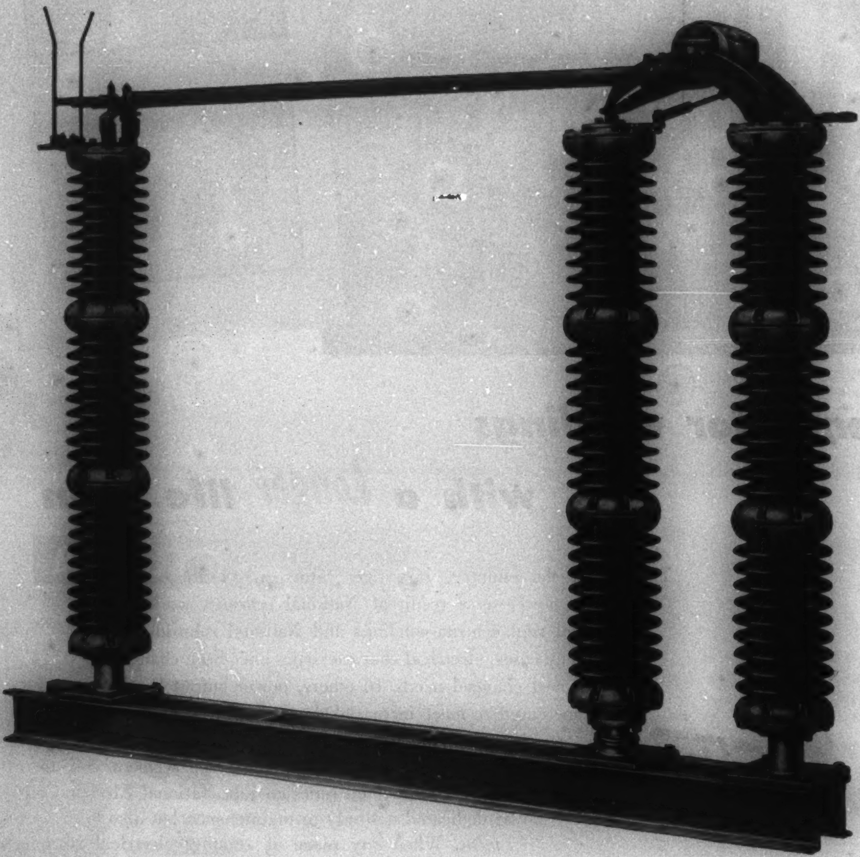

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